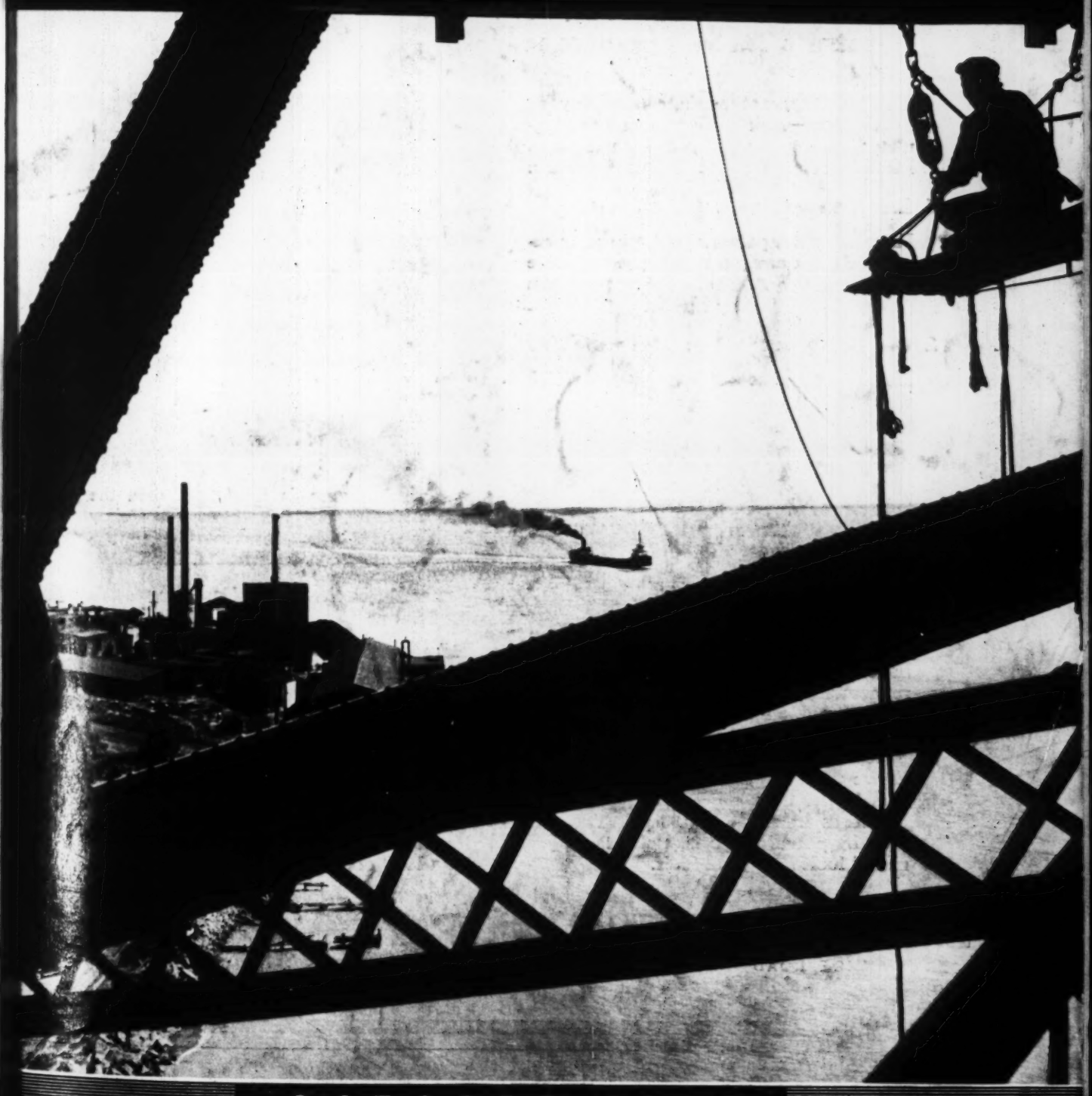
MECHANICAL ENGINEERING



OCTOBER 1946

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 68 NUMBER 10

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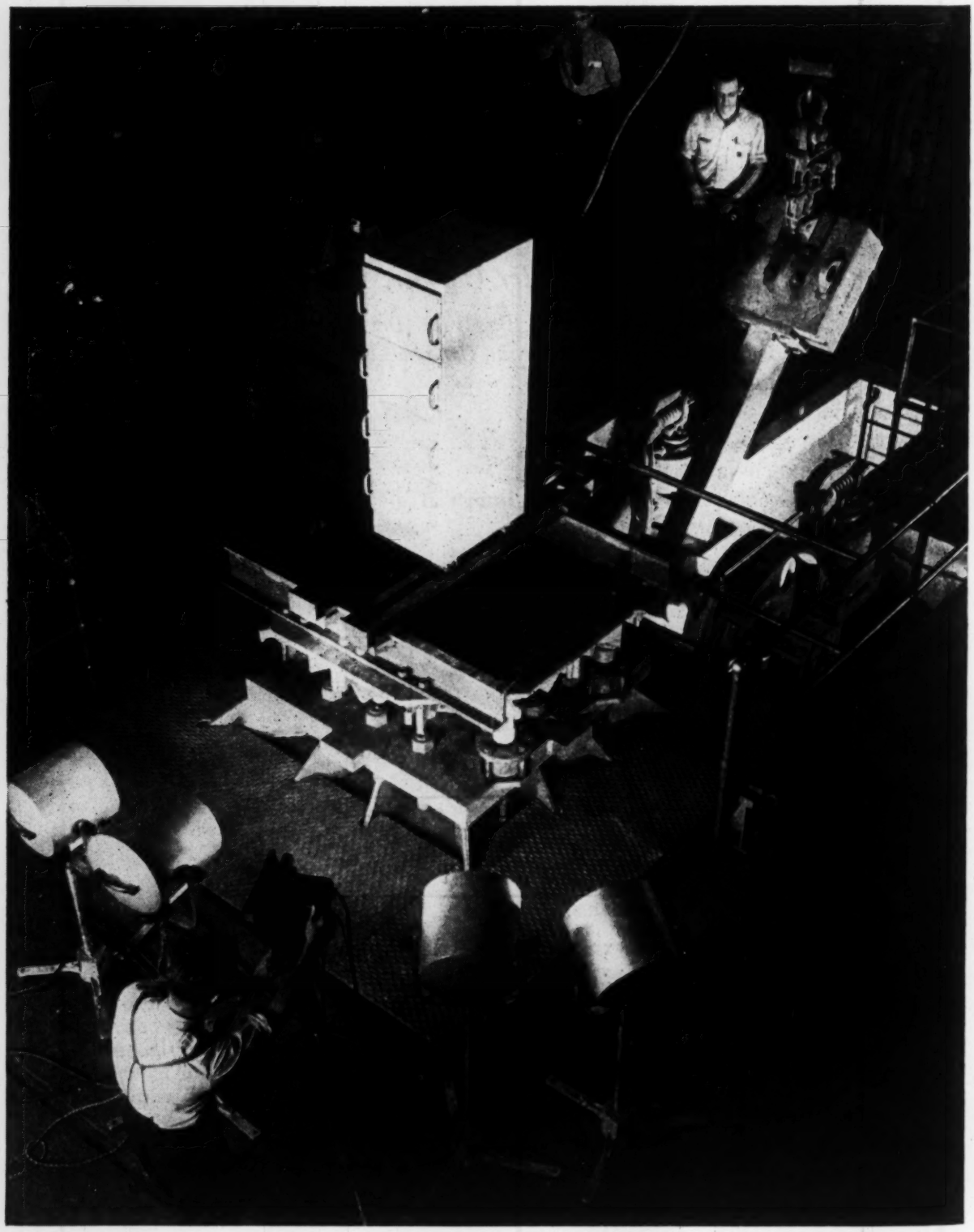
Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the head quarters of the Society, 29 West Thirty-Ninth Street, New York 18, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the amiling list. Please send old as well as new address. . . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1946, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.



High-Speed Movies, A New Research Tool

(The operator at the left is taking motion pictures at 4500 fps of a cabinet to house electrical apparatus as it undergoes a 5500-ft-lb impact test at the Westinghouse Electric Corporation, Pittsburgh, Pennsylvania. The 3000-lb hammer in the rear has been raised to the exact height to produce the impact desired when dropped. It swings through an arc and strikes the underside of the platform on which the cabinet is bolted, thereby imparting the terrific impact. When these films are projected at 16 fps failures resulting from such severe shock are easily analyzed.)

VOLUME 68
No. 10

MECHANICAL ENGINEERING

OCTOBER
1946

GEORGE A. STETSON, *Editor*

A. R. Stevenson, Jr.

IN THE sudden death, on August 28, of A. R. Stevenson, Jr., staff assistant to the General Electric vice-president in charge of engineering policy, and vice-president of A.S.M.E., his friends and associates have suffered a grievous loss.

Contacts with Dr. Stevenson, either in conversation or through correspondence, were always satisfying experiences which produced a sense of having been intellectually invigorated. The imaginative mind of the man explored the subjects that engaged his attention with a thoroughness and impartiality that amazed men accustomed to holding traditional views and those who thought superficially, if they thought at all. The spirit that animated his inquiries was that of a man trained in his early youth to respect the power of the truth and by environment and professional contacts to apply the scientific method to questions that confronted him. Imagination in his case was under the control of judgment and a consciousness of practicability which lent it direction and force without fettering it to atrophy in frustration. Where a man with less intellectual equilibrium would allow novelty or wishful thinking to upset him, Dr. Stevenson adhered to principles in which he had faith, whether they applied to the natural sciences, to human nature, or to economics. These qualities made him particularly helpful as a critic, and when some of his friends wished to have their own ideas evaluated, they appealed to him with gratifying results.

Dr. Stevenson's interests in education were broader than those of the average educator. It was his contention that everyone was interested in education and that education was one of the strongest threads of common concern which shot through the pattern of A.S.M.E. programs. When discussions of curricula ran in narrow channels he used to point out that he had studied civil engineering at Princeton, that his early work at General Electric had been in the field of electrical engineering, and that ultimately 95 per cent of his engineering interests had been in mechanical engineering. What was important in this experience was the realization that fundamentals of fact and method underlie all engineering problems. His professional interests in education stemmed from the fact that he assisted General Electric's six operating departments and laboratories with their educational and training programs and co-ordinated these programs from a company-wide standpoint, but they had a universal quality which embraced all education from primary to postgraduate and adult levels.

Dr. Stevenson's talents in the use of imagination and in stimulating his associates to enter new fields were strikingly demonstrated shortly after he became a member of the A.S.M.E. Committee on Education and Training for the Industries. At a single committee meeting he outlined more new and useful activities than the committee could undertake in many years. Chief among these was a series of sessions for the discussion of inventiveness, intuition, and creative imagination and how to develop these qualities in young engineers. So thoroughly did he convince his colleagues of the importance of these subjects that they not only elected to follow his suggestion but persuaded the Meetings and Program Committee to introduce the Annual Meeting programs with a general luncheon (without other competing events) at which prominent speakers discussed the subjects from various angles. After three years of successful luncheons and addresses, he persuaded the committee to switch the subject to training for leadership. In these relationships with his fellow committeemen he not only exemplified the qualities of creative imagination and leadership which he proposed for discussion, but also a maxim he frequently quoted: It is not enough to be right; one must also be persuasive.

Dr. Stevenson was a constant and purposeful reader. He shared the fruits of his reading with his friends. It was his practice to call their attention to the books he had read; but he also sent them lengthy excerpts of the books, quoting the passages that had seemed to him to be most significant. Many of his friends will miss this extraordinary service.

Dr. Stevenson became a vice-president of the A.S.M.E. at a time when Society reorganization demanded new and enlarged services of the vice-presidents. Men of initiative and enthusiasm, thoroughly versed in the ideals and objectives of the Society and familiar with its organization and its activities, were needed to fill these posts. The duties were new and onerous and the way had to be felt out step by step. Into this task Dr. Stevenson threw himself wholeheartedly. As time proves the effectiveness of the new plan of assigning a vice-president to each of the Society's eight geographical regions, Dr. Stevenson's contributions to the success of the plan will be gratefully remembered.

Although Dr. Stevenson's career was spent in industry, it was, in the larger sense, devoted to the advancement of engineering education. If one believes as he did that the need and opportunity for education do not end with the college but continue throughout life, one can credit him with having made significant contributions to that latter phase. If engineering education at the college level suffered because Dr. Stevenson could not be induced to serve

it as professor, dean, or president, it gained at the industrial level by the work which he carried on at General Electric. And in those areas of engineering education that concern engineering societies and the engineering profession, Dr. Stevenson was an active worker. Where educational matters were discussed his advice was eagerly sought and freely given. There are many besides the writer of this tribute who will no longer be able to answer a perplexing question by saying, "I must write Alec about that!"

The Physically Handicapped

IT is reported that 28 million persons in the United States have some physical disability that is more or less permanent. Most of these have disabilities that do not prevent them from doing useful work, but two and one half million persons of working age have permanent disabilities which do interfere with their getting or holding suitable jobs. It is further reported that 85,000 disabled civilians and 228,000 disabled veterans are now ready for work and are seeking employment through the U. S. Employment Service; that, according to the National Rehabilitation Service, at least 1,500,000 civilians can be restored to working condition; and that 100,000 disabled veterans are in training under the Veterans Administration, soon to be ready to enter the labor market.

Many industrial establishments have retraining programs for the physically handicapped and their employment policies are set up to do their part in providing suitable jobs for handicapped persons. These persons do not want sympathy but opportunities to take their place in the world as normal self-supporting citizens. Engineering ingenuity should not find it a difficult task to provide this opportunity.

Smithsonian Centennial

ENGINEERS should be glad to pay tribute to the Smithsonian Institution which has just completed 100 years of service to pure and applied science. The home of the Smithsonian Institution has long been a familiar landmark in Washington and for forty years has provided, in addition to its own staff and activities, headquarters for the American Association for the Advancement of Science with which many engineers are affiliated through the Engineering Section. Since 1880 the Smithsonian has maintained, as a division of the National Museum, a department of engineering and industries; and, through the International Exchange Service which started in 1849, libraries, scientific societies, and institutions, among them The American Society of Mechanical Engineers, have found an easy and inexpensive way in which to ship their publications to libraries and institutions in other lands.

The Institution was founded by James Smithson, a scientific investigator, who bequeathed his fortune to the United States of America "to found at Washington an establishment for the increase and diffusion of knowledge among men. The act which brought the Smithsonian into being was signed by President James K. Polk, on Aug. 10, 1846, and the plan of organization was set up by Joseph Henry, first secretary of the Smithsonian, one of the foremost of American physicists, known to all students of electrical engineering for his pioneering work.

The work of the Smithsonian Institution has been carried on through scientific research in many fields, worldwide explorations, publications, and other means by which Smithson's objective could be attained. Out of these activities have grown up around the Institution several bureaus—the U. S. National Museum, the International Exchange Service, the Bureau of American Ethnology, The National Zoological Park, and the Astrophysical Observatory. Although these activities remain bureaus of the Institution, their support, in whole or in part, has been assumed by the government. The Smithsonian is also charged with responsibility for national art treasures. The National Art Gallery is a bureau of the Institution but is directed by a separate Board of Directors.

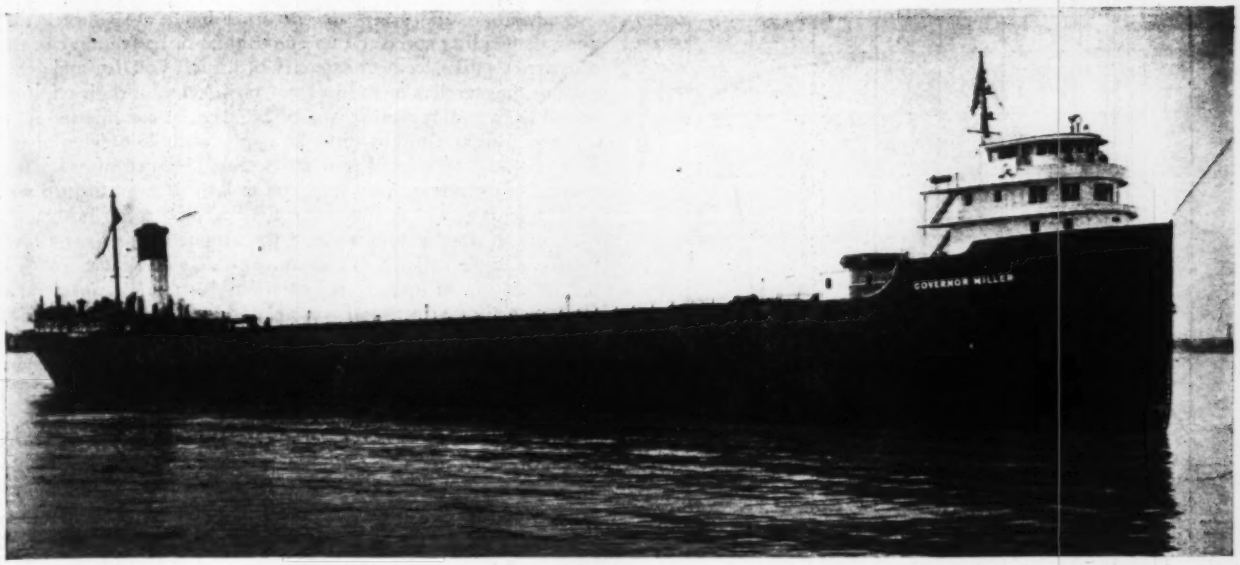
In commemoration of the Smithsonian centennial, *Science* devoted its issue of August 9 to articles on the Institution and its bureaus and activities. The articles constitute an impressive record which cannot be summarized here. In the first of these articles, Alexander Wetmore, present secretary, Smithsonian Institution, writes:

"From one building, a small staff, and a single publication, the Institution has grown in a century until it now occupies five buildings on the Mall and numerous structures at the National Zoological Park, while it issues 14 publications, each devoted to a particular sphere.

"The main influence of the Institution has centered in its scientific staff, its series of publications, and its collections. The first comprise the heart of the organization. . . . . The publications of the Institution constitute one record of its accomplishment in the fields of scientific culture. The collections are the base for much research and investigation and in addition are a scientific and cultural archive that the Institution guards on behalf of the Nation."

Scrap

THE Committee on Iron and Steel Scrap of the American Iron and Steel Institute has appealed to us to direct attention to the need for scrap in the steel industry. The Society got vigorously behind the drive for scrap during the war and has been complimented on the effectiveness of its appeals during those critical years. Today not enough scrap is available to the open hearths and reconversion programs are affected by this shortage. Engineers do not need to be reminded of the importance of scrap in the steel industry. Reasons for the current shortage are several, and our contemporaries, *Iron Age* and *Steel*, keep readers informed of the progress of programs to alleviate the conditions which cause the shortage. Whatever individuals and corporations can do to increase the flow of scrap to the open hearths will eventually benefit themselves by increasing the output of the steel mills and the materials needed for manufacture.



PITTSBURGH STEAMSHIP COMPANY FREIGHTER LEAVING AMERICAN SHIP BUILDING COMPANY YARD ON HER TRIALS

The GREAT LAKES BULK-CARGO CARRIER

By L. A. BAIER

CHAIRMAN, DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING, UNIVERSITY OF MICHIGAN

THE principal link in the most efficient transportation system in the world, the bulk carrier, represents a development in engineering symbolic of American enterprise.

BASIC REQUIREMENTS OF LAKE SHIP DESIGN

The recordings of the tremendous saga concerning the expansion of the Midwest since Jean Nicolet first paddled through the Straits of Mackinac in 1634 are delightfully gathered in the five volumes on the Great Lakes, edited by Milo M. Quaife (25).[1] Together with the story of the "Long Ships Passing," by Walter Havighurst (1), we can likewise view the history of shipping plying our vast inland oceans of "sweet water." From sail to steam and Diesel, for 300 years commerce and settlers have traversed these waters, challenging the builder of boats, and later the naval architect and shipbuilder to meet and solve ever-changing demands for efficient transportation.

Since the ill-fated 60-ft *Griffen*, built in 1679, at Cayuga Creek above Niagara, carried La Salle to Green Bay and was lost on the return trip loaded with furs, the design of lake vessels has reflected the physical limitations and cargo characteristics found nowhere else in the world. Large bodies of open water, shoal connecting rivers and locks made necessary by the 350-ft difference in altitude between Ontario and Superior have directed the design and proportions of the lake carrier widely different from coastwise and ocean vessels. The current limiting dimensions above Ogdensburg are as follows:

Upbound depth	21 ft
Downbound depth	25 ft
Welland Canal locks	765 ft × 80 ft
St. Mary's River locks	1300 ft × 80 ft

From Ogdensburg to Montreal, six locks are limited to 252 ft × 44 ft × 14 ft over the sills. In addition, available seasonal depths in lower lake ports, increased or decreased by prevailing winds, further limit the loading drafts. Full-time navigation is ice-restricted, totaling 225 to 250 days in the year, except for the car ferries operating continuously across Lake Michigan, the Straits, and the Detroit River.

The type of suitable carrier also has changed with the supply and demand of various cargoes as the upper-lake wilderness was exploited and the lower-lake industries consolidated. Furs downbound and supplies and immigrants upbound were followed by ore and lumber cargoes with coal returning.

Today the principal cargoes are ore, limestone, coal, grain, cement, and oil. Pulpwood, automobile parts, steel and scrap, new cars and trucks, dairy products, sand, railroad car ferries and passenger service form important traffic but require comparatively little tonnage. Fig. 1 illustrates the yearly flow of the major cargoes of ore, coal, and grain over the past 40 years. Ore is given in gross tons while grain and coal are noted in net tons. A summary of the vessels employed in this lake traffic is given in Table 1.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Materials Handling Division and presented at the Semi-Annual Meeting, Detroit, Mich., June 17–20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

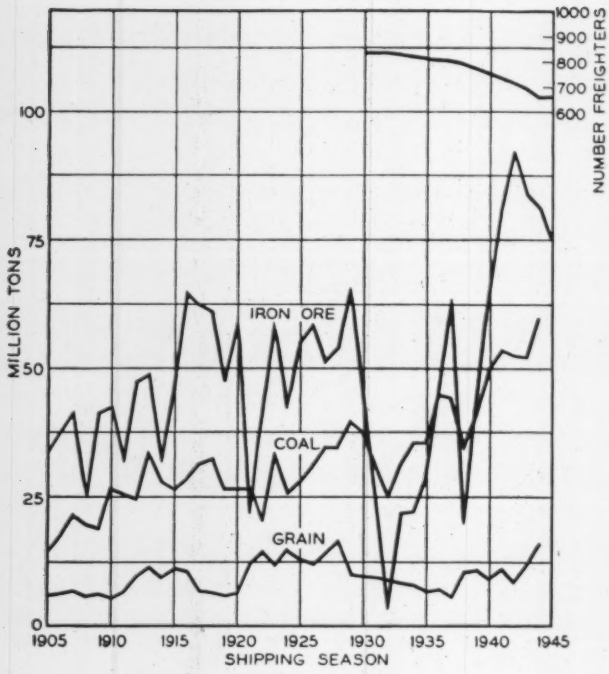


FIG. 1 LAKE BULK FREIGHT BY YEARS

Although Fig. 1 indicates a steady decline in the number of lake freighters from 1930 to 1945 of about 173, or 21 per cent, the over-all fleet capacity, in fact, has been consistently maintained at about 4,500,000 gross tons per trip. The annual retirement of the smaller vessels also is reflected by the yearly increase in average ore cargo per ship per trip, currently being about 11,000 gross tons

The distinctive outboard view of the typical lake freighter is, of course, familiar to many readers; about 600 ft in length with narrow beam, the machinery is located aft and pilothouse forward, permitting a clear length for cargo hatches amidship. The nearest counterpart in seagoing vessels is the bulk oil tanker. Several factors have operated to standardize the modern lake design to a degree seldom possible in other trades. These will become evident in further discussion.

General Design. Since cargoes are bulk in nature, loading and unloading port facilities were naturally designed to take maximum advantage of this feature. Multiple ore chutes spaced on 12-ft centers determine the location and dimensions of hatches. Ease of shifting the vessel under coal or stone loaders also demands a continuous cargo space unbroken by deckhouses. Long holds with widely spaced bulkhead, self-trimming, and clear of stanchions, are necessary. Low speeds permit efficient forms with comparatively short entrance and run, embodying long parallel middle bodies and high block coefficients. The afterend carries the propelling machinery, bunkers, quarters for engine-room force, and mess facilities. Forward are the deck-crew quarters, windlass space, guest rooms, and pilothouse. Single-screw-propelled, the majority of the fleet is steam-driven and coal-burning.

Ore is a "dead-weight" cargo, hence requiring emphasis on buoyancy or displacement and wasteful of internal capacity. Tank tops are high, reducing the cargo lift and minimizing excessive stability. Ample room is available for wing tanks, with inclined inboard sides, for ballast when upbound light. The old whaleback or "pig," represented a design to eliminate unused space, reduce tonnage measurement and, in the case of grain, reduce the shifting of the free surface.

Coal, stone, and grain, on the other hand, are "cubic" cargoes, demanding space and unable to take full advantage of the ore carrier's displacement capacity or draft. For this and other reasons, ore carriers operate a large proportion of their trips upbound light. A typical season of 240 days in commission for a mid-age freighter might show 29 trips; with 28 cargoes of ore at 80 cents, 5 cargoes of coal at 45 cents, 1 cargo of grain at 6 cents, for a steaming run of 50,000 miles. The grain load was held in storage, say at Buffalo or Erie, at 8 cents per bushel.

Short earning seasons with 4 to 5 months' layup and low-income freight call for minimum capital investment. With a maximum run in open water of about 30 hr and considerable time spent in rivers, shoal waters, and maneuvering, efficiency of the power plant at reduced revolutions is of importance. The economics of a new design obviously requires the maximum spread between income per ton and cost per ton-mile, or a return of the investment in the shortest number of years. Since depreciation is generally based upon a life of 40 to 50 years, many of the factors are unforeseeable and assumptions are not always realized. Size, displacement, cubic capacity, speed, and power depend on probable freight rates, choice of trade, percentage of full use, improvements in channels, and port facilities.

An economical study (10) made some years ago at the University of Michigan still is of interest. Since the ultimate dimensions have now become fairly well established, the designer's principal concern today is in the proper choice of speed and power. A slight recession from recent high-power installations may be anticipated with perhaps more consideration given to Diesel drive.

Over the last 10 years the average loading time in upper lake ports was 5 hr 22 min and in lower lake ports, discharging, 9 hr 12 min. During the same period the fastest loading time ran from 1 hr to 2 hr 5 min, with 8068 tons per hr as an average rate. Other loading marks cover a cargo of 13,877 short tons of coal plus 369 tons of bunker coal in 4 hr 30 min; 555,000 bu of wheat in 7 hr 20 min; 7145 short tons of stone in 38 min Unloading records are likewise remarkable: 11,445 long tons of iron ore discharged in 2 hr 20 min; 9366 short tons of coal in 6 hr 5 min; 451,382 bu of wheat in 15 hr. An interesting difference between the design of ocean and lake vessels is that in the latter field available cargo is limited only to the vessel's capacity or channel restrictions. Many ocean vessels are limited in size due to the inability to assemble sufficient cargo within economical periods in port.

Table 2 illustrates the growth in dimensions over the last 40 years as channel and dock facilities were improved. The gradual acceptance by owners of the advantages of the larger vessel is apparent.

Length. Experience has proved the economic advantage of the large vessel on the lakes. During periods of business recession, the smaller boats first are laid up, and it was during such a depression that the self-unloader came into popular use. Old ships with tank tops due for renewal were converted and found markets unavailable to the bulk carrier. It is doubtful whether the present length will be materially increased in future designs; 620-ft keel length is about the limit for convenient winding a ship in certain slips; and difficulties of maneuvering, with delay time, in restricted waters are exaggerated for vessels of excessive length. It is true that many of the smaller boats still are profitable to operate, mainly because of the fact that their age has resulted in the original investment being written off through past depreciation entries.

Beam. The maximum beam will probably be limited for some years to not more than 70 ft. The fixed optimum reach of the present loading and unloading rigs makes difficult the proper trimming of the cargo in the holds for greater beams.

TABLE 1 SHIPS ENGAGED IN LAKE SERVICES

No.	Type	Trade	Flag	Gross registered tonnage	Carrying capacity, gross tons at 20 ft draft
		BULK FREIGHTERS IN IRON ORE TRADE			
302	Steamers	Ore, coal, grain	U. S.	1906225	2850690
2	Motorships	Ore, coal, lumber	U. S.	17524	23750
4	Steamers	Ore, coal, sulphur	U. S.	15697	23300
2	Barges	Ore	U. S.	8304	15700
5	Barges	Ore, coal, grain	U. S.	19795	35600
36	Steamers	Ore, coal, grain	Canada	204376	301400
4	Barges	Ore, coal, grain	Canada	13565	24100
355		Total		2193490	3286735
		SELF UNLOADERS			
34	Steamers	Stone, coal	U. S.	196524	277316
3	Steamers	Cement, coal	U. S.	9233	15290
9	Steamers	Coal	Canada	26841	34150
1	Steamer	Cement, coal	Canada	4346	4600
1	Motorship				
48		Total		236944	331356
		BULK FREIGHTERS IN MIXED TRADES			
7	Steamers	Steel, scrap, coal	U. S.	20116	30000
13	Steamers	Grain, coal	U. S.	51068	77200
9	Motorships	Barge canalers	U. S.	12367	21500
12	Steamers	Sand	U. S.	15261	21450
5	Steamers	Coal, grain	Canada	20093	28700
81	Steamers	Coal, grain, paper	Canada	148767	227600
8	Motorships	Coal, grain, paper	Canada	15719	24700
4	Steamers	Sand	Canada	3609	4900
11	Barges	Coal, grain, pulp	U. S.	30040	50850
11	Barges	Coal, grain, pulp	Canada	30325	52300
161		Total		347365	539200
		PACKAGE FREIGHTERS			
4	Steamers	Grain	U. S.	16095	18000
4	Steamers	Package, grain	Canada	12514	12900
18	Steamers	Package, grain	Canada	37856	48500
26		Total		66465	79400
		OIL TANKERS			
15	Steamers	Petroleum	U. S.	57697	81950
4	Motorships				
7	Motorships	Canalers	U. S.	8170	17100
10	Barges	Oil	U. S.	11845	17000
26	Steamers	Oil	Canada	48919	71500
4	Motorships				
4	Barges	Oil	Canada	3956	6600
70		Total		130587	194150
660		Sub total		2974851	4430841
		CAR FERRIES			
24	Steamers	Railroad	U. S.	69102	....
4	Steamers	Passenger and auto	U. S.	7792	....
3	Steamers	Railroad	Canada	11766	....
31		Total		88660	....
		PASSENGER STEAMERS			
13	Steamers	Passenger	U. S.	44998	....
6	Steamers	Passenger	Canada	23829	....
6	Steamers	Passenger	Canada	13154	....
25		Total		81981	....
716		Grand total		3145492	....

Draft. Present channel depths and freeboard requirements restrict the current draft to 24 ft downbound 35-ft molded depth of hull. Load lines are established for all merchant vessels on the Great Lakes of 150 gross tons or over in conformity with the Coastwise Load Line Act, October, 1935, amended June 20, 1936, and effective as to vessels of 4000 gross tons and upward, November 27, 1935, and as to all other vessels subject thereto August 27, 1936. These freeboard rules limit many of the older vessels to drafts of 22 ft or less and only the modern design can take advantage of the now available 24-ft operating draft. Freeboard, and hence draft, is assigned for winter (November 1 to April 15); intermediate (April 16 to May 15); (September 16 to October 31); and the summer season (May 16 to September 15). The reduction in draft for a vessel of 24-ft summer draft would be about 24-in. during the winter season and about 11 in. for the intermediate term. Freeboard is basically a function of length and depth, with adjustments and allowances for sheer, beam camber, superstructures, adequate longitudinal section modulus, and certain safety and structural details.

TABLE 2 INCREASE IN DIMENSION OF LAKE FREIGHTERS

Year	Length over-all, ft	Keel length, ft	Beam, ft	Depth, ft	Power, ihp	Mph	D.W. capacity gross tons
1895	479	459	48	28	1500	12	6800[c]
1898	476	456	50	28	2200	13	6900
1900	498	478	52	29	1500	11	7700
1904	560	540	56	32	2000	12	9700
1905	578	557.8	56	31	1800	11 1/2	9800
1906	601	580	58	32	1800	11 1/2	10500
1906	604	586	58	32	1900	11 1/2	10700
1907	605.8	585	60	32	1800	11 1/2	10800
1909	607	580.8	58	33	1800	11 1/2	10800
1911	617	590	64	34	2500	12 1/2	11800
1922	620	602.8	64	33	2400	12 1/2	12000
1924	611	590	62	32	3200[a]	13	10900
1926	633	613	70	29	3000	12	14250
1927	620.8	604	64	33	2700	12 1/2	12500
1927	630.8	607	65	33	2800	12 1/2	13000
1930	604	580	60	32	2200	12	11300
1938	610.8	586	60	32.5	2000[b]	12	14215[d]
1942	639.5	602	67	35	4000[b]	14	18300[e]
1943	620	595	60	35	2500	12 1/2	16000[e]

[a] Brake horsepower.
[b] Shaft horsepower.
[c] Draft, 19 ft.
[d] Draft, 22 ft.
[e] Draft, 24 ft.

Speed. An inspection of Table 2 indicates only a moderate increase in speed over a long period of ship design. This is a natural consequence of the low freight rates, and the use of standard power plants. For a proposed design several speeds with corresponding power requirements are assumed and curves derived for income and operating cost. Fuel cost is a dominant factor in operation, and modern design of boilers and machinery permits the use of higher powers at the same fuel outlay. Machinery weight and initial cost also rise with power, and maintenance is an important factor. Certain trades and routes will support higher speeds, and the possible gain of a single additional round trip in limited season must be considered. There are other factors, however, which also tend to control higher speeds. As these lake forms are pushed, the power curve rises rapidly; excessive squat will occur in channels; suction and wave formations may cause damage; and a check-down in speed is frequently necessary due to traffic lanes in the rivers.

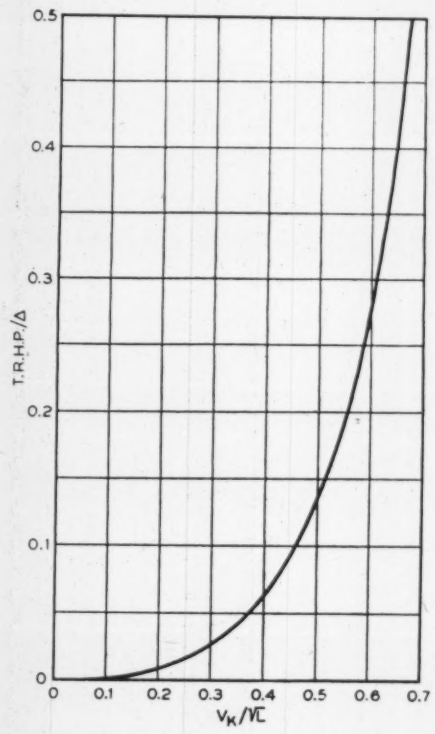


FIG. 2 COMPOSITE TOWROPE-HORSEPOWER CURVE

Form and Power. For some 40 years the Naval Tank at the University of Michigan, under the direction of Dr. H. C. Sadler, Prof. E. M. Bragg, and currently the author, has been concerned with the testing and refinement of hull designs for Great Lakes vessels of all types. The bulk freighter operates at speed-length ratios ($V_k/\sqrt{L}$) of about 0.5, in contrast to an ocean-going ore carrier (steamship *Venore*) of 560 ft, steaming at 16 knots (18 1/2 mph) for a $V_k/\sqrt{L}$ of about 0.665 with a deadweight capacity of 24,250 tons at 35 ft, 2 3/4 in. draft. In the latter case a block coefficient of 0.755 contrasts with 0.87 to 0.88 in the lake carrier.

The parallel middle body includes about 50 per cent of the length with a section coefficient of about 0.99. The dead rise is 3 to 4 in. for docking purposes, and the bilge radius generally 3 to 4 ft. The standard sheer required by the freeboard rules results in unusable cubic forward and aft plus increased weight of hull so considerably lower sheer is adopted with an acceptance of increased freeboard.

The entrance will use about 23 per cent of the length, and the sections are fairly well standardized. Very little flare can be used topsides due to the possibility of damage to dock rigs when the vessel is working on a forward spring line with the stern away from the pier.

The run is made up of the remainder of the length and has been subject to considerable improvement through recent research. On some of the older vessels large moss-covered areas on the after buttocks indicated excessive wake and poor flow. A slight increase in the length of run, together with the adoption of the cruiser stern has decreased the towrope horsepower 5 per cent, and in addition has provided better flow to the wheel. The wake at the propeller is high, 40 to 50 per cent, but some gain is recovered owing to the possibility of designing the wheel to turn at lower revolutions, with consequent higher efficiency. The incorporation of twisted sternposts for contraflow effect to the wheel, and bulbous sections at the lower aft end of the keel to equalize the wake, appear to be worth while in the gain to propulsive efficiency. An important feature of the cruiser stern has been the reduction in squat, especially in shoal water.

The final choice of length of entrance, parallel middle body and run practically determines the longitudinal position of the center of buoyancy, which in turn must be vertically in line with the fore-and-aft location of the center of gravity of the loaded vessel in order to insure no trim. Freedom of form de-

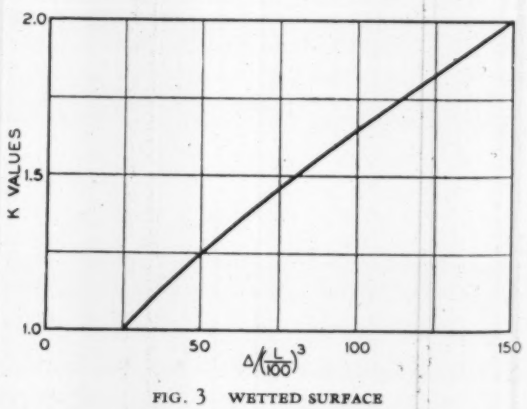


FIG. 3 WETTED SURFACE

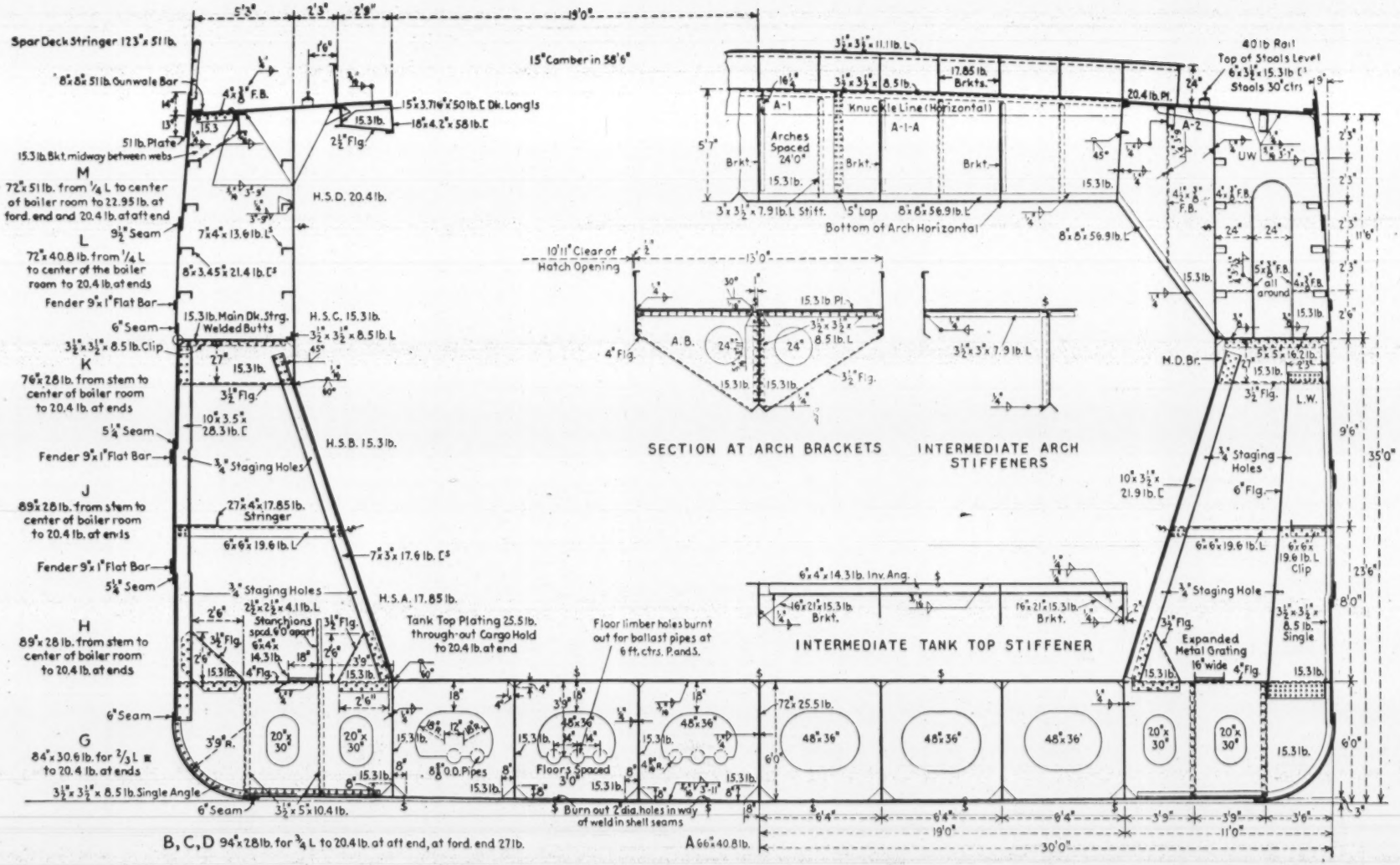


FIG. 4 MIDSHIP SECTION WITH TRANSVERSE FRAMING

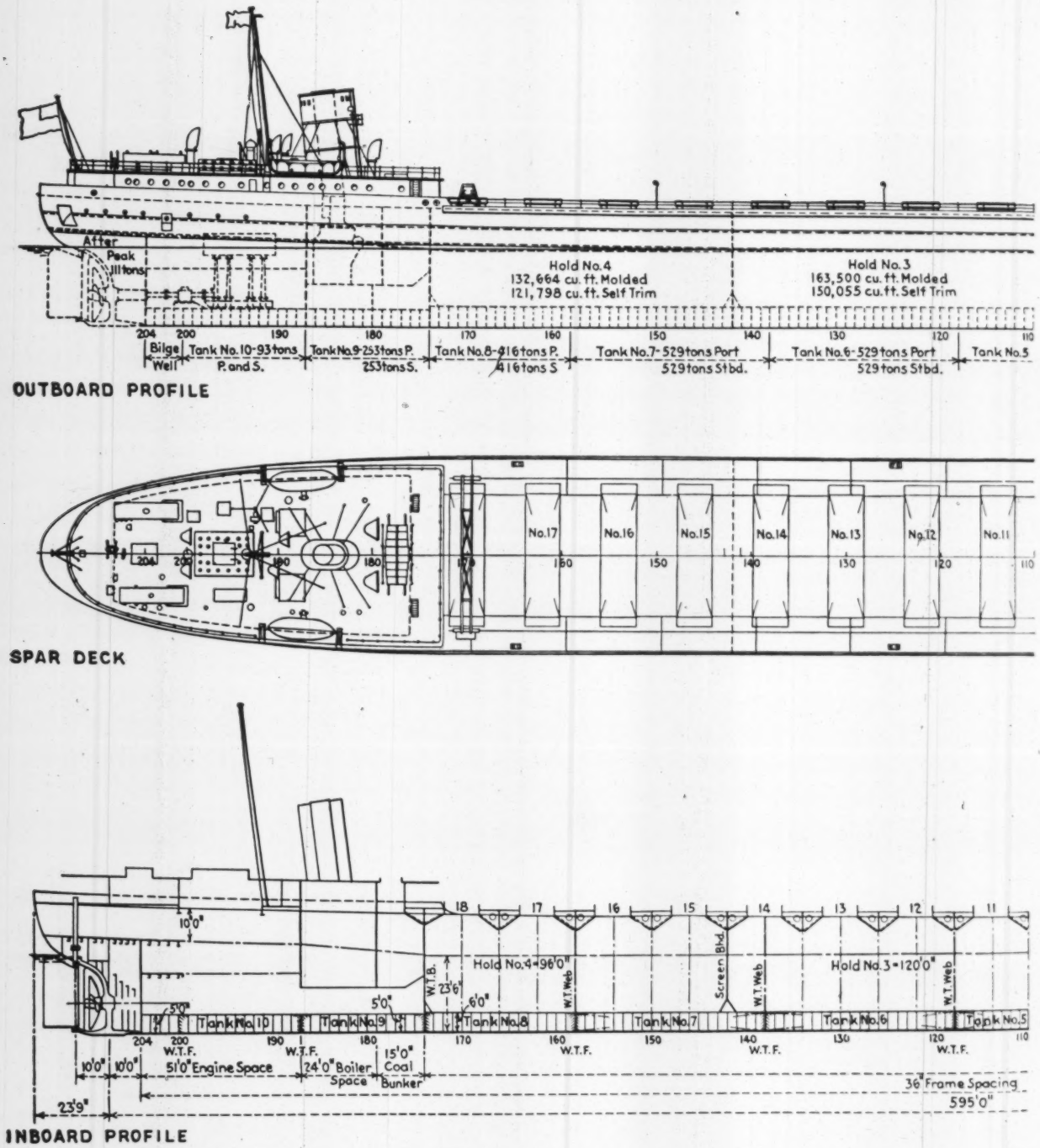


FIG. 5 OUTBOARD PROFILE FOR MARITIME

sign therefore is always somewhat restricted or compromised to balance internal arrangements, hatch locations, and structural requirements.

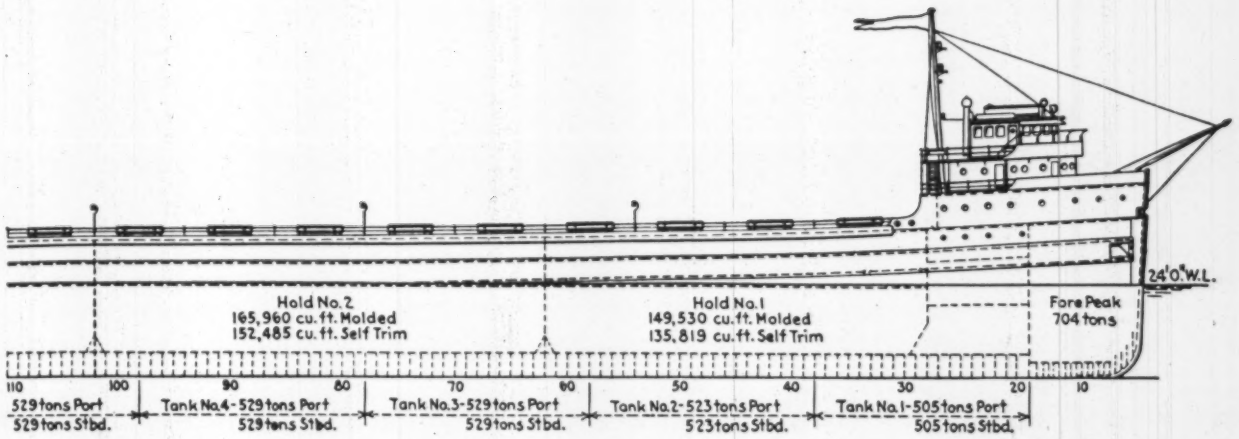
The installed power is rated as ihp (indicated horsepower) for reciprocating engines; bhp (brake horsepower) for Diesels; and shp (shaft horsepower) for tubines or electric drive. The shp is measured just aft of the thrust block and hence is the unit of torque common to all types of machinery. After allowing for the shaft-bearing and stern-tube losses, the final torque at the propeller is designated as the dhp (delivered horsepower).

From the resistance viewpoint the power necessary to tow the vessel is known as the trhp (towrope horsepower) or ehp (effective horsepower). The ratio trhp/dhp is called the pc (propulsive efficiency) and is the relation between the thrust and torque, the converting unit being the propeller. The trhp is made up of the following components:

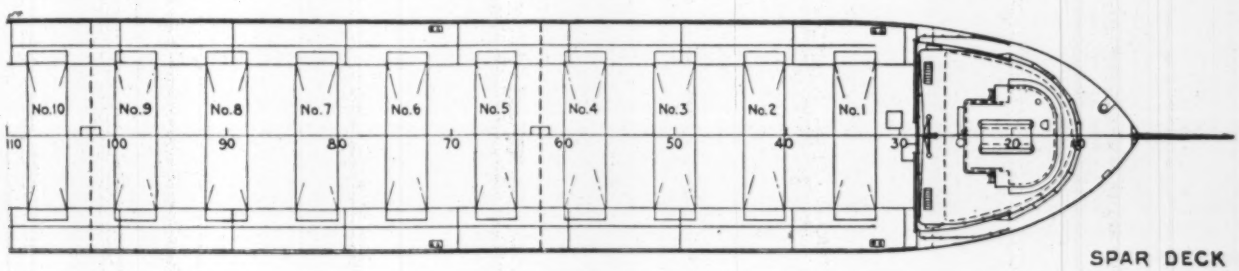
Smooth-surface friction resistance	fhp
Extra power for surface roughness	rhp
Power for appendage resistance	ahp
Still-air resistance of above-water hull	sahp
Wave- and eddy-making resistance	whp

The fhp+rhp will account for 70 to 80 per cent of the trhp and may be estimated by the following formula:

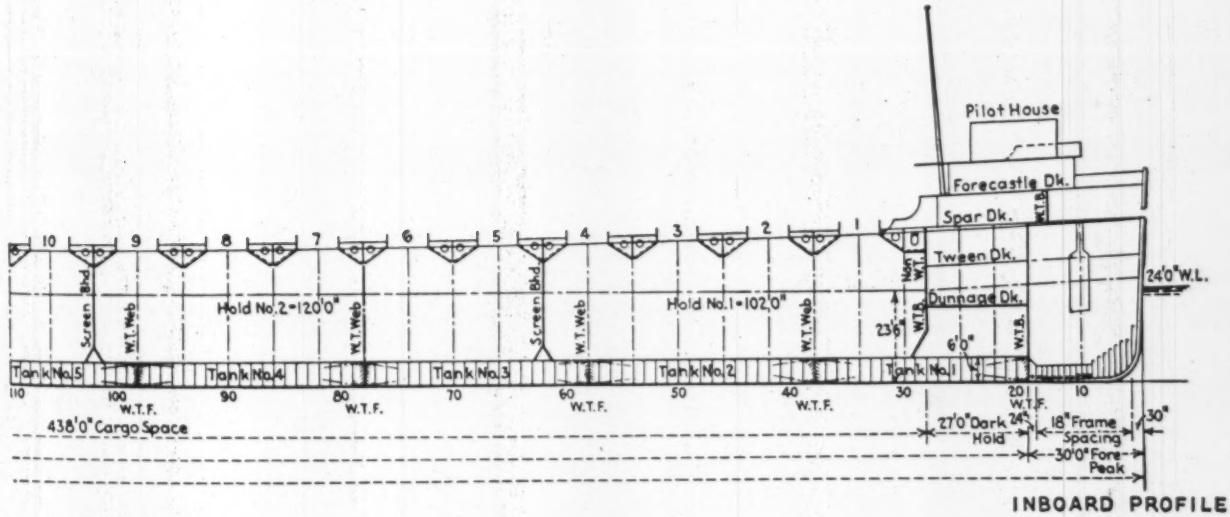
$$(\text{fhp}+\text{rhp}) = 1.0216\ (0.008486 + 0.0516/8.793 + L)\ S \times$$


Hold No. 2
165,960 cu. ft. Molded
152,485 cu. ft. Salt Trim
Hold No. 1
149,530 cu. ft. Molded
135,819 cu. ft. Salt Trim
Fore Peak
704 tons
24'0" W.L.
529 tons Port
529 tons Stbd.
Tank No. 4 - 529 tons Port
529 tons Stbd.
Tank No. 3 - 529 tons Port
529 tons Stbd.
Tank No. 2 - 523 tons Port
523 tons Stbd.
Tank No. 1 - 505 tons Port
505 tons Stbd.

OUTBOARD PROFILE



SPAR DECK



INBOARD PROFILE

$V_k^{2.525} \times 0.00307$ where S = wetted surface in sq ft, L = length in feet, and V_k is the speed in knots.

The wetted surface compares favorably with other vessels on a displacement basis and may be estimated from the expression

$$S = \frac{L^2 \times K}{10}$$

where K is a function of length and displacement. Values of K are shown in Fig. 3.

Since the trhp is largely made up of frictional resistance, it is not very sensitive to possible form differences in the lake-carrier type. Wetted surface being a function of length and displacement, it is possible to predict trhp with reasonable accuracy on a displacement basis. Fig. 2 shows a composite plot, for several freighters, of $trhp/\Delta$ (towrope horsepower per ton of displacement) based on $V_k/\sqrt{L}$. These values have been improved on by recent designs but still are representative of the usual power requirements in service.

The major improvements in power economy have resulted in the last few years through attack on the propulsive efficiency, $pc = e_0 \times C$, where e_0 is the open water, or inherent hydraulic efficiency of the propeller, and C is a factor representing the net effect of the hull on the wheel, and the augment of resistance produced by the propeller on the hull. The propeller oper-

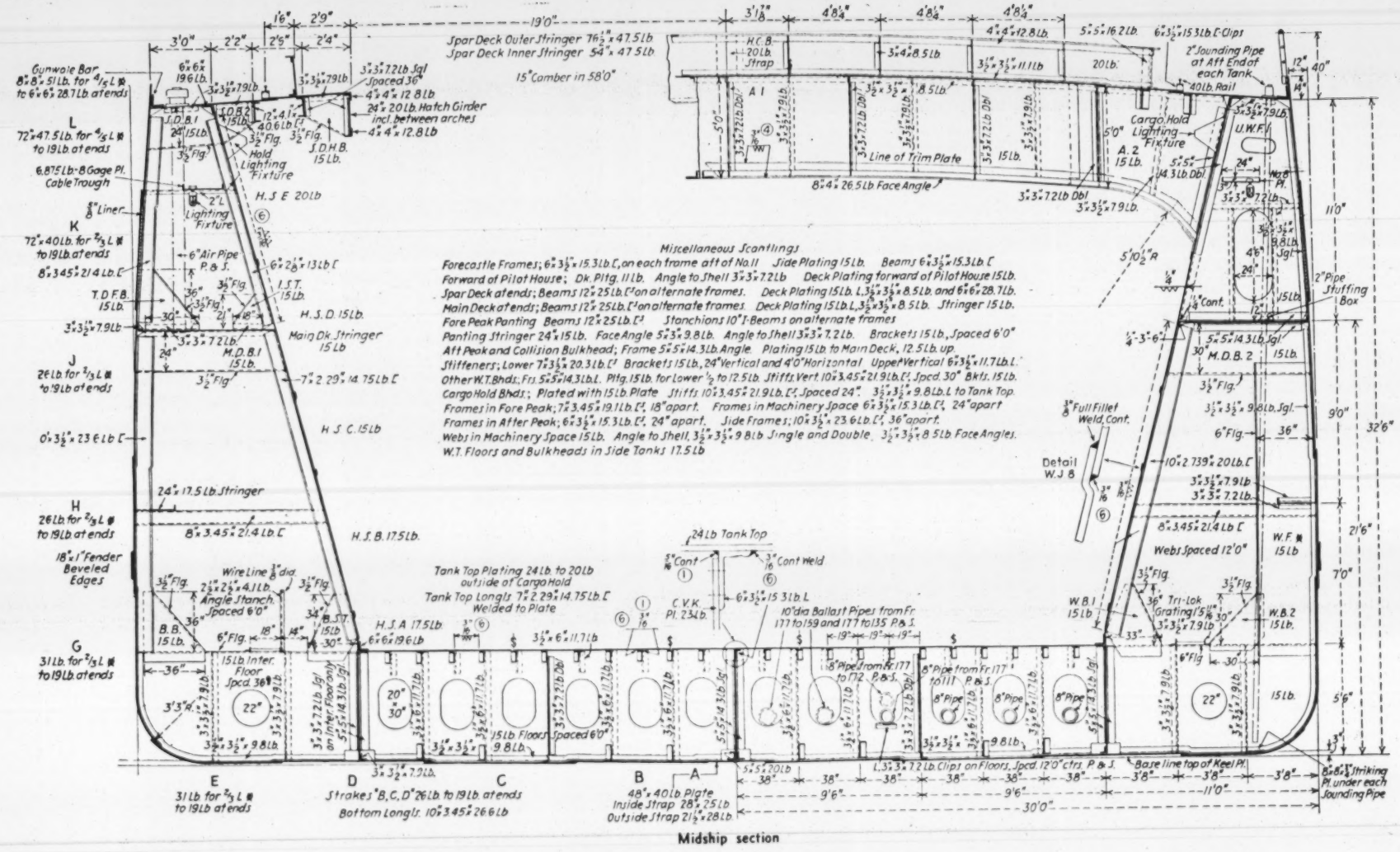

Spar Deck Outer Stringer 76½" x 47.5 Lb
Spar Deck Inner Stringer 54" x 47.5 Lb
15" Camber in 58'0"
Gunwale Bar 8"x8"x51 Lb. for 4/5 L to 6"x6"x28.7 Lb at ends
L 72"x47.5 Lb. for 4/5 L to 19 Lb. at ends
6.87.5 Lb-8 Gage Pl. Cable Trough
K 72"x40 Lb. for 2/3 L to 19 Lb. at ends
J 26 Lb for 2/3 L to 19 Lb at ends
H 26 Lb for 2/3 L to 19 Lb at ends
18"x1" Fender Beveled Edges
G 31 Lb. for 2/3 L to 19 Lb. at ends
E 31 Lb for 2/3 L to 19 Lb at ends
D Strakes "B, C, D" 26 Lb to 19 Lb at ends
Bottom Longls. 10"x3.45"x26 6 Lb
B 48"x40 Lb Plate
Inside Strap 28"x25 Lb
Outside Strap 21½"x28 Lb
Miscellaneous Scantlings
Forecastle Frames; 6"x3½"x15.3 Lb [, on each frame aft of No.II Side Plating 15 Lb. Beams 6"x3½"x15.3 Lb [
Forward of Pilot House; Dk. Ptg. 11 Lb. Angle to Shell 3"x3"x7.2 Lb Deck Plating forward of Pilot House 15 Lb.
Spar Deck at ends; Beams 12"x25 Lb. [on alternate frames. Deck Plating 15 Lb. L 3½"x3½"x8.5 Lb. and 6"x6"x28.7 Lb.
Main Deck at ends; Beams 12"x25 Lb. [on alternate frames Deck Plating 15 Lb. L 3½"x3½"x8.5 Lb. Stringer 15 Lb.
Fore Peak Panting Beams 12"x25 Lb. [Stanchions 10" I-Beams on alternate frames
Panting Stringer 24"x15 Lb. Face Angle 5"x3"x9.8 Lb. Angle to Shell 3"x3"x7.2 Lb. Brackets 15 Lb., Spaced 6'0"
Aft Peak and Collision Bulkhead; Frame 5"x5"x14.3 Lb. Angle. Plating 15 Lb. to Main Deck, 12.5 Lb. up.
Stiffeners; Lower 7"x3½"x20.3 Lb. [Brackets 15 Lb., 24" Vertical and 4'0" Horizontal Upper Vertical 6"x3½"x11.7 Lb. L
Other W.T. Bhds.; Frs. 5"x5"x14.3 Lb. L. Ptg. 15 Lb. for Lower ½ to 12.5 Lb. Stiffs. Vert. 10"x3.45"x21.9 Lb. [, Spcd. 30" Bkts. 15 Lb.
Cargo Hold Bhds; Plated with 15 Lb. Plate Stiffs 10"x3.45"x21.9 Lb. [, Spaced 24". 3½"x3½"x9.8 Lb. L to Tank Top.
Frames in Fore Peak; 7"x3.45"x19.1 Lb. [, 18" apart. Frames in Machinery Space 6"x3½"x15.3 Lb. [, 24" apart
Frames in After Peak; 6"x3½"x15.3 Lb. [, 24" apart. Side Frames; 10"x3½"x23.6 Lb. [, 36" apart.
Webs in Machinery Space 15 Lb. Angle to Shell, 3½"x3½"x9.8 Lb Single and Double. 3½"x3½"x8.5 Lb Face Angles.
W.T. Floors and Bulkheads in Side Tanks 17.5 Lb
Midship section

FIG. 6 MIDSHIP SECTION WITH LONGITUDINAL FRAMING

ates at slips of 40 to 50 per cent where e_0 will be about 50 to 55 per cent for a modern design. Through use of solid bronze wheels, contrafins, contrarudders, fairing plates on the stern-post, and twisted stern-frames values of C up to 1.37 have been obtained, with resulting pc values of as high as 0.735. The foregoing features, installed on existing carriers through co-operation between the University of Michigan Naval Tank and The American Ship Building Company, have shown gains of 5 per cent in speed and 8 per cent saving in coal consumption.

Structure. Figures 4, 5, 6, and 7 were obtained through the courtesy of The American Ship Building Company and are valuable supplements to this paper. The midship section, illustrated in Fig. 4, covers many details of construction for the design of the recent fleet built for the U. S. Maritime Commission. The framing is transverse below the main-deck stringer in the holds, and at the ends of the ship. The upper side shell, upper wing bulkheads, and spar deck are longitudinally framed. About 50 per cent of the vessel is welded.

Fig. 6 is a midship section of the recent vessels built for the Pittsburgh Steamship Company, and depicts the use of longitudinal framing throughout the double bottom and spar deck, using transverse framing on the sides. Welding is extensively used, although the vessels are essentially a riveted job. References (22) and (24) cover the numerous construction and arrangement details and need not be repeated here.

The standards of longitudinal strength were first outlined by Dr. Sadler and Professor Lindblad of the University of Michigan in 1922 (9). The results are incorporated in the freeboard regulations covering required longitudinal modulus, where

$$I/y = f\,d\,B$$

I = moment of inertia of midship section about neutral axis, calculated in way of openings but without deduction for rivet holes
y = distance from neutral axis to strength-deck beam at side
d = draft at summer freeboard
B = beam of ship
f = factor given in rules as function of length, being equal to 15.30 for 600 ft. However, values of f for existing vessels with various types of framing average 10 to 30 per cent greater than the required factor for a 600-ft ship (15).

Reference (15) also gives calculated stresses for various conditions of loading in still water, and in waves of 300 ft × 20 ft, although waves of greater length and height are frequently encountered on the lakes. Dr. Sadler suggested a permissible longitudinal stress equal to $\sqrt[3]{L}$, or about $8^1/_2$ tons per sq in. for a 600-ft vessel. In practice these stresses seldom approach the value just given.

A standard value of $C = 0.35$ in the formula $C = I/lbd$, also proposed by Dr. Sadler, is closely approximated by existing values of 0.32 to 0.37 for different types of framing.

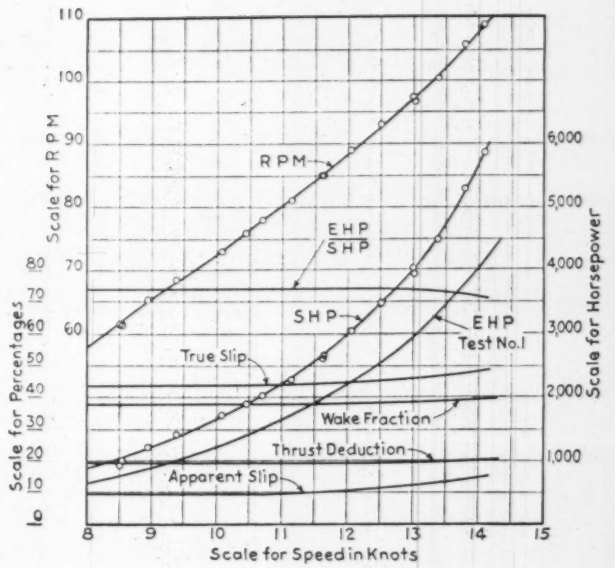


FIG. 7 SELF-PROPELLED MODEL TESTS ON MARITIME COMMISSION ORE CARRIERS

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AERIAL CAMERAS

Their History and Development as a Precision Instrument

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PHOTOGRAMMETRY as a science is described in modern dictionaries as "the making of photographic measurements." As such it embodies all the various fields of medical or clinical photography, x-ray, photomicrography, stereoscopic photography, and aerial photography.

The application of photogrammetry through the medium of aerial photography is commonly known as aerial surveying. Surveying is also described as the delineation of distances and directions on paper for the purpose of making a map.

Peoples of the world have always been map-conscious, and this condition has been fostered to such an extent that at the present time there is not a single project connected with transportation, communication, group maneuvers, construction, reforestation, mining, soil conservation, or international, national, or local development, that is not first thought out from preliminary maps.

Because the making of maps is the fundamental part of any project, the information contained therein must be accurate and more or less detailed. Surveying is therefore engineering in the strongest sense of the word, and is taught in some form or other in most schools and colleges throughout the world. It is one of the oldest of sciences, being in use in Biblical times as a means of restoring boundaries washed away by the overflowing Nile River.

True it is, that photogrammetry had the same early beginning, for Aristotle referred to the "optical projection of images" in 350 B.C.; but not until centuries later did Leonardo da Vinci describe the "camera obscura." Mathematical treatises on analysis of perspective projection began to appear in 1521.

The development of cameras with lenses, the chemistry of photography, and the mathematics of perspective projection, had progressed to such an extent by 1802 that printed silhouettes were being made on sensitized leather. Wheatstone was experimenting on a method for making quantitative studies of photographs and eventually worked out the theory of stereoscopy in 1838.

Progress was rapid in the nineteenth century, with extended research in sensitizing material, stereoscopy, and three-color photography. Laussedat in 1819 conceived the idea of utilizing terrestrial photography in the compilation of topographical maps. His research was held in ridicule as was the work of Nadir in 1856 who explored the possibilities of using aerial photographs for the same purpose. In 1851, the French Academy of Sciences demonstrated the application of photography to topography and architecture for the design of monuments.

This history of the beginning of photogrammetry is given to show that the early scientists were aware of the potentialities involved.

Present-day engineers are gradually accepting aerial photography as a sound supplementary mapping method, a tool of modern mapping. It is a means to an end, but not an end in itself. Such consideration is the stumbling block of photogrammetrists. It seems inevitable that aerial surveying must in time become indispensable for mapping; in some inaccessible territories it has already assumed priority.

The accuracy and economy of the aerial photographic method depends to a considerable extent on the excellence and suitability of the photographs to be used for measurement.

The suitability of the photography is particularly determined by the geometrical arrangement of the component photographs, but the excellence of the photography is due chiefly to the optical and mechanical properties of the aerial camera itself Two of the most important specifications concerning manufacture are stated herein for the purpose of showing what is expected of aerial cameras.

The aerial camera is a surveying instrument. Its place in the field of aerial surveying is similar to that of the transit or theodolite in terrestrial surveying. Our present ground surveying instruments are not all of the same degree of accuracy. The same applies to aerial cameras. True, also, is the fact that results obtained with our best cameras do not reach the degree of precision obtained with our better telescopic surveying instruments, but present-day research is working rapidly to obtain a better comparison of instruments.

The original aerial cameras were of necessity very crude instruments as compared to the standards of today. As the perfection of roll film did not take place until about 1890, the early instruments used either the wet- or dry-plate method of photography. Each instrument was designed and built according to the whims and desires of the scientist doing the research work. Regardless of design, shape, or size, each camera contained a plateholder, lightproof chamber, and lens. Very likely early camera lenses were taken from spectacles used by the scientist or ground to his personal specification by an oculist

The size of the first aerial cameras was limited due to the fact that they were transported either in balloons, kites, or rockets. It is even recorded where one experimenter actually secured photographs with miniature cameras attached to pigeons, and to mention the other extreme an 8-lens camera was transported aloft in the basket of a balloon during German army maneuvers in 1911.

For a period of 20 years previous to 1911, many experimental tests had been made on various carriers for the aerial camera with the consensus of expert opinion in favor of the balloon. It was expected that this procedure would be followed in 1914 at the outbreak of the first world war; such expectations went amiss as was demonstrated in August of that year when a captured Zeppelin was found to contain an aerial camera, as did a German airplane shot down soon afterward.

Aerial motion pictures were taken from an airplane piloted by Wilbur Wright in 1909. Although this event was followed by many others of a similar nature, practical aerial photography dates from the early days of World War I. Airplanes had been developed by that time and were in regular use by most armies by 1914, and although the airplane was considered to be the ideal carrier, it was not until Lieut. Laws of the British Air Corps brought back actual aerial pictures of enemy territory

Contributed by the Aviation Division and presented at the Semi-Annual Meeting, Detroit, Michigan, June 17–20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

that the obvious value of the pictures as a source of military intelligence was realized.

It is a strange fact that out of the carnage of war should come a method of engineering of such a practical and useful nature; but the evidence as brought back by Lieut. Laws was to start a feverish research program on the part of the Allies to develop suitable aerial cameras. The development of practical carrying agents in the airplane had far outstripped the development of picture-taking equipment, and modern aerial photography can be said to date from about this period, in 1914.

An interesting angle to bring in at this time, concerning subsequent development and manufacture of this equipment is that there are so few companies in this type of business. Only three countries have produced any considerable amount of aerial photographic equipment and these are Germany, Great Britain, and the United States. The fact that there are few aerial-camera manufacturers in various countries is probably due to:

1 Small normal peacetime demand.
2 Extensive development programs necessary.
3 Unusually precise workmanship required.
4 Need for expert and experienced designers and craftsmen.
5 High cost of marketing a specialized device.

Due to the nature of the equipment and its great military value, the United States Army Air Forces and United States Navy Bureau of Aeronautics have been responsible from the very start for many of the broad principles of design, by virtue of the requirements they themselves have set up to be met by the camera equipment they purchased from the manufacturer.

The aerial cameras produced by each of the previously mentioned countries have definite characteristics. The German cameras running true to their mechanized line of thinking are rather complex in their operation, requiring a very highly trained technician for operation. The British cameras are just the opposite, being quite simple in design and easy to operate. The most outstanding feature is the unit design which makes it possible to manufacture any minor or major component in many different factories and ship all to a central assembly plant for completion. This feature of course is much more valuable in wartime than in normal times. The American-make aerial cameras have greater ruggedness, longer life, and are far simpler to operate than either of the other two, but this is achieved at the expense of size and weight.

In the years intervening between the first and second world wars, there were relatively few types of American aerial cameras. The research programs necessary to develop this equipment should have been initiated if not actually underwritten by the military agencies of the country. But in the years following World War I the accent was on demilitarization and discontinuance of everything of this nature, or a continuation on a very much reduced scale. A few years ago, any discussion of the subject of aerial cameras would be very limited and would consist of the fact that there existed two general classifications of aerial cameras, single-lens cameras and multiple-lens cameras. At the present time, the multiple-lens camera is militarily obsolete, but will be mentioned briefly in this paper.

In general, it can be said that all types of single-lens cameras consist of certain main component parts: lens, lens cone, shutter, camera body, drive mechanism, and the film magazine.

LENSES

The lens obviously is the most important part of the camera. It is the part through which the perspective picture is recorded, and if it is hoped to obtain precision in the preservation of the correct angular relationship of the "bundle" of rays in the object space, when they are brought into the image space and recorded on a photograph, the greatest care must be taken in the design and manufacture.

Photographic lenses are designed for specific types of work. A lens designed for copying maps, for instance, would not be satisfactory for use in a precise aerial mapping camera. In the former case, the lens is designed to give good definition and low distortion for finite object distances while in the latter case, the lens is designed for an infinite distance only.

Aerial-camera lenses are usually mounted in barrels composed of a front element and a rear element so that either element can be unscrewed separately from the mounting, which in many cameras also forms the housing for the shutter. When the front and rear elements are identical, the lens is symmetrical; when they are different, the lens is asymmetrical. If the several elements are ground as segments of a sphere, the lens is spherical; if ground to different curves, the lens is aspherical.

There are certain well-known and recognized lens manufacturers whose quality of workmanship is accepted as a byword. Such manufacturers assign serial numbers to their product and honor them with a trade-mark. If the trade-mark is recognized, the lens if undisturbed can be depended upon to be a good lens. Aerial photographic lenses are made of the best quality of optical glass and the workmanship is in accordance with the high-grade commercial practice covering the manufacture of precision optics.

The lens manufacturer is interested in eliminating in so far as possible the errors inherent in all lens systems, mainly: spherical aberration, coma, astigmatism, curvature of the field, longitudinal and lateral chromatic aberration, and distortion.

The lens user is mainly interested in distortion and "definition." The latter term is used to express the ability of a lens to record fine detail. It may be expressed as the resolving power which refers to the maximum number of lines per millimeter that can just be seen as separate lines in the image.

In an attempt to obtain a near-perfect lens, designers have tried many different combinations, the variables at the disposal of the designer being index of refraction, dispersive power, curvature of glass and number, thickness and spacing of the elements. Since it is impossible to design a perfect lens, a balance must be arrived at between the most desired properties. Examples of this balancing are found in the wide-angle aerial-camera lens where low distortion, good definition, and large angular field are secured at the expense of maximum aperture.

The wide-angle lens is the preferred type for mapping work, although there are certain types of aerial photography requiring a different design.

The size of the lens angle is measured by the rays emerging from the lens in the form of a cone. The size of the apex angle being the measure of the lens, that is, if the apex angle is 50 deg, it is known as a conventional 50-deg-angle lens. Generally speaking, those lenses with an angle greater than 80 deg are known as wide-angle lenses.

The data for determining the size of the angle are the focal length and one half of the diagonal measurements of the aerial film used. The ratio of these two distances being the tangent of one half the lens angle. As the standard size for aerial film ranges 4×5, 5×7, 7×9, 8×10, 9×9, and 9×18 in., it can readily be seen that shorter-focal-length lenses must be wide-angle in order to completely expose the negative, while the longer focal lengths are usually the conventional type.

Before a lens is mounted in an aerial camera, it is subjected to several tests known as the optical laboratory and camera tests.

The laboratory tests obtain quantitative measurements of front, back, and equivalent focal lengths, distortion, and resolving power. The camera test determines the distortion and definition for the focal length actually set in the camera at the time the test was made.

The essential features of a lens for aerial photography are great rapidity and freedom from all aberrations. In order to obtain a clearly defined image, the lens must be a definite distance from the plate or film. This distance when the lens is focused on a distant object is called the focal length. The focal length does not change but is fixed by the curvature of the glass and the value of the focal length is said to be the size of the lens. It goes without saying therefore that aerial cameras must be of fixed focus because their objective is at approximately the same distance during each exposure.

The focal length of aerial-camera lenses ranges from $5^1/_4$ in. to 40 in., with the 6-in., $8^1/_4$-in., 12-in. and 20-in. being the most practical for mapping purposes. It is here interesting to note that the Germans were experimenting on two extremes in focal lengths, one a $3^1/_4$-in. and the other a 60-in. This measurement also has an important bearing on the over-all size of the camera itself, because it determines the length of the lens cone.

The lens cone in its truest form is a truncated metal cone containing the lens (and possibly a shutter if it has what is known as a between-the-lens shutter) at one end and a means of attaching to the camera body at the other. This cone must be long enough to contain the lens at its proper distance from the plate or film, hence the larger the focal length the larger the lens cone.

The cone can be made in several ways. Its purpose as stated previously is to contain the lens at a proper distance from the film and to prevent light coming to the underside of the film from any source other than the lens.

It can be made in the form of an integral aluminum or white-metal casting, with ribs and supporting framework as part of the casting. The lens barrel then is simply screwed into the casting. It can also be made in parts, with the ribs and supporting framework that will contain the lens being made from a material with low thermal expansion, such as invar steel. The entire framework is then covered with a metal spinning to give the general contour of the cone. By this latter method especially, the lens alignment is free from any dimensional changes and is in line with the general specifications for precision camera design.

AERIAL CAMERA SHUTTERS

The shutter serves to admit or exclude light from the camera and because of this is the second most important part of the camera in point of design. In general, there are three types of shutters:

1 Between the lens
2 Focal plane (curtain)
3 Louver

each with its advantages and disadvantages. The function of all three is the same, namely, to prevent light from reaching the film emulsion except for the brief instant the photograph is being made. Important characteristics are, speed, accuracy, efficiency, and life.

The speed of a shutter is the length of time, a fraction of a second, from the instant when the shutter just begins to admit light until it cuts off the light. In aerial cameras, this time interval for a between-the-lens shutter ranges from $^1/_{25}$ of a second to about $^1/_{500}$ of a second. For louver shutters, about the same speed can be obtained, but with a focal-plane shutter a higher speed up to $^1/_{1000}$ of a second can be obtained. Thus the focal-plane shutter is particularly adapted to military operation involving low-altitude high-speed photography.

Accuracy of a shutter is expressed as a per cent of the elapsed time, and it is customary to require that the top speed be accurate within 10 per cent. Shutter speed accuracy is an important item in color photography which is still very critical regarding exposure time. The efficiency of a shutter must be known before the quality of a shutter can be evaluated. Efficiency is expressed as the ratio of the amount of light admitted to the lens through a complete cycle of opening and shutting to the amount of light admitted if the shutter were completely open during the entire cycle.

Shutter life is the period over which it can be depended to operate with specific accuracy without failure. This is most important from a practical point of view as unexpected failure of the shutter brings a photographic mission to an end. You can well imagine the monetary loss to a commercial operator or a military loss to an army if this should happen. The life is expressed in cycles and most military specifications require that shutters have a life of 10,000 cycles.

Between-the-lens shutters are located between the components of the lens. In this position it will admit as much light as the lens. The name is derived from the fact that the shutter leaves operate in the fraction of an inch separating the front and rear elements of an aerial-camera lens. It is the most popular type in the United States today because of its durability, mapping applications, and absence of obstruction in lens aperture. It has the effect of instantly cutting off all light passing through the lens. This characteristic of the between-the-lens shutter which enables it to admit light or cut it off from the lens instantaneously, preserves in the negative precise relationship of all object points photographed. The resulting photographs can be used confidently as no errors will be present as a result of shutter operation.

The shutter itself consists of a thin-metal-leaf assembly actuated by a cam assembly and controlled by a retard governor to permit exposures of longer duration. The motivating power for all assemblies is stored in a coil spring. A built-in trip mechanism releases the coil spring, starting the exposure cycle.

A focal-plane shutter is so named because it operates close to the focal plane front of the film, and is so arranged that at the instant of exposure it will travel across the film. A slit is provided in the curtain and as it moves across the film it successively exposes the various positions of the film. The curtain consists of a piece of closely woven, light, flexible cloth impregnated with crude rubber. The size of the slit varies and depends on several factors and ordinarily ranges from $^1/_8$ to 1 in. in width. The motivating power is a tension spring on the opposite roller. As the slit travels across the film an image is formed on the negative in successive bands, and when the slit passes beyond the negative area the exposure is completed.

This exposure is only made by the shutter when it moves in one direction; however, unless means were provided to avoid it, light would be admitted to the film when the curtain is wound back to starting position. Thus we have what is known as a capping curtain which is immediately brought across the film before rewind of the shutter curtain starts.

The fundamental principle of operation of the focal-plane shutter introduces positional errors in the relationship of object points photographed of varying magnitudes, consequently, it should not be used for mapping purposes but, as mentioned before, for certain types of military reconnaissance this elongation or positional error is immaterial.

Focal-plane shutters contribute to reducing the cost of aerial-camera equipment which utilizes interchangeable lens cones. Since the focal-plane shutter is located in the camera body, the lens cones consist only of a simple truncated cone and a lens.

The focal plane is a plane wherein all light rays passing through the lens come to a focus. The plane is bounded by a metal frame which determines the area of exposure of the negative. The plane itself may be one of two types, the open

type or the plate-glass type. If glass, it is held in the frame and is the same size as the negative used and so located in the camera that it is perpendicular to the central axis of the lens. Either type must provide some means to hold the film tight against the focal-plane glass or, if the glass is removed, in the focal plane itself. It is relatively simple with a glass focal plane, as a metal pressure plate presses the film against the glass just before exposure takes place, and releases after the exposure has been made and the film can be advanced.

If the negative size is not greater than 4 × 5 in. the film can be held flat by means of direct tension.

If no focal-plane glass is provided and the negative area is greater than 4 × 5 in., air pressure or vacuum (preferably vacuum) must be used. The vacuum method is most popular in today's precision cameras, vacuum being obtained by means of aircraft Venturi, vacuum pump, or self-contained piston; however, under certain unfavorable conditions the Venturi has become dogged and pumps have failed to work due to rarified air at high altitudes. Considerable success has been achieved by the cylinder and piston method, which has the added advantage of making the camera independent of hose connections to the aircraft.

The open-type focal plane, at least in so far as American aerial cameras are concerned has replaced the glass-plate type for all but very elementary types of aerial cameras. With the glass removed, the focal plane becomes a plane in air, requiring a metal frame known as a locating back to hold the film in the exact focal plane. With this frame, the edges of the film at least lie in the focal plane and the sag in the central portion can be controlled by air pressure or vacuum.

Another feature of the focal plane is that it contains the fiducial or collimation marks. These are identifying marks which are reproduced on the negative and are used to locate what is known as the principal point of the negative and photograph. Fiducial marks are of importance only in aerial cameras whose photographic product is used for photogrammetric purposes. The idea is to locate the marks so lines joining opposite marks will intersect at the principal point.

In cameras used for low-accuracy mapping, the fiducial marks are located by the manufacturer to indicate the geometrical center of the focal-plane opening. In precision manufacturing this geometrical center agrees closely with the principal point. In precision cameras the marks must be adjustable so the principal point will be located very accurately, within 0.036 millimeter, and the lines from opposite marks will intersect at 90 deg ± 30 sec.

In the case of the glass focal plane, these fiducial marks are etched on the surface in contact with the film, and thus their image on the film is obtained. In the open type the marks are triangularly shaped metal projections which extend into the negative area. Adjustments are allowed by slotted holes, but after perfect adjustment they are permanently fixed in position. This adjustment must be done by the National Bureau of Standards.

The louver shutter is similar in appearance and effect to a venetian blind. These shutters have been very popular on foreign-made cameras, especially the British, and are used in Europe with lenses of any focal length; but in the United States they have been used mostly on long-focal-length wide-aperture lenses because the moving parts of a "between-the-lens" shutter are too large for fast speeds. They admit light to the film similar to the between-the-lens shutter, but do not have the disadvantages of the focal-plane shutter.

In the camera, the louver shutter is usually placed in front of the lens, or immediately in back of the lens, and in few cases has been inserted between the elements. In any case, they should be placed as close to the lens element as possible. The efficiency of this type of shutter is not as high as the other types mentioned. An appreciable amount of light is cut off from the exposure by the combined thickness of the leaves.

CAMERA BODY

The camera body contains the camera drive mechanism, motor, operating levers, electrical connections, switches, and other special details that may be included. The lens cone bolts to the bottom of the camera body, while the top of the body forms a seat for the camera magazine. Regardless of whether a camera is manually operated or automatic, every camera has its drive mechanism which performs two main functions: (1) wind or cock the shutter, (2) advance film.

The camera drive mechanism is contained in the camera body, located between the lens cone and the magazine. It is the power unit and power distributor for the entire camera. Rods extending downward from the drive mechanism, and male connectors extending upward to the magazine, transmit power from the camera drive to the shutter and film, thus both are operated simultaneously. When both are fully wound or when a complete cycle has been made, the camera drive on receipt of an electrical or mechanical impulse operates the shutter, thus taking a picture.

In automatic aerial cameras, an electric motor is mounted in the camera body as close as possible to the drive mechanism. The motor operates on either 12 or 24 volts, although the modern trend is toward 24-volt operation. The power of the motor varies with the size and design of the camera. An important characteristic of the drive mechanism is the time required for a complete operating cycle, which consists of all operations performed in order to trip a fully wound camera and restore it to a fully wound condition again. Certain aerial-camera uses require that photographs be taken at very close intervals, thus the use to which it is to be put determines the operating cycle which must be considered in the camera design. The shortest cycle at present is $^1/_3$ of a second, and the largest is 10 seconds.

The last component part of an aerial camera, but by no means the least, is the film magazine whose main functions are to: (1) Contain the film; (2) to advance new film; (3) to measure exact amount of film for each exposure; (4) to hold film flat in the focal plane.

There are two general types of magazines, namely, integral and detachable, each with certain advantages and disadvantages. The integral type is designed as part of the camera body, and contributes to lightness and reduced cost. This is obtained, however, at the expense of carrying the entire camera into a darkroom for reloading, and if any part of the mechanism of the magazine fails, the entire camera is out of service.

The detachable is by far the most popular and practical for aerial photography. This type has its own drive mechanism which is operated by the camera drive mechanism. Several of these can be loaded and carried in the plane on any photographic mission and quickly changed when required.

The capacity of a magazine is expressed either as the maximum length of film it can contain or as the number of exposures which can be made on that length of film. Some magazines have capacity for only 40 negatives, and others vary up to about 650 negatives requiring a 500-ft roll of film.

In an aerial camera designed for precision photography, it is of great advantage to automatically record certain data concerning the photographic mission. This can be done through a recording data chamber contained on the outside of the cone itself and through reflected illumination and supplemental lenses, the pertinent data are transferred to the film. These data are so arranged that they occupy but very little of the photographic area, a space about $^5/_{16} \times 1^1/_2$ inches.

The data chamber will contain a small card with the name of the mission, dates, and names of crew members. Next to the card is the exposure counter which indicates the number of pictures taken, then comes a level bubble for registering tip and tilt of the camera at the instant of exposure followed by a clock to indicate the time of day of each exposure. These instruments are all in the same horizontal plane. Immediately in back of the serial counter and in a vertical plane is an altimeter. The image of this altimeter is rectified to the horizontal by means of a small reflecting prism. The image of the entire panel of this recording chamber is projected as previously mentioned at a greatly reduced scale at the instant of exposure.

AERIAL-CAMERA SPECIFICATIONS

The entire discussion up to this point has been on generalities covering single-lens aerial-camera construction; and it might be said that aerial cameras can be made in any shape or form as long as they perform the main operating functions as described. This may be true as there are many ways to obtain an end result, but there must be something more than just plain workmanship going into a camera designed to do the precision mapping as required by the U. S. Geological Survey and other governmental agencies. The type of camera to be used on any job will be stated in each invitiation to bid and the general characteristics of each camera must comply with certain very strict specifications concerning focal length, negative size, film width, type and location of fiducial mark, minimum field of lens, lens and lens-cone assembly, shutter, lens and shutter assembly, and camera mount.

In order to build a camera to abide by these specifications it requires the highest grade of skilled technicians experienced in machining and finishing to very close tolerances every working and moving part within the camera, because each component part of the camera has a particular job to perform in the schematic operation. All this is an effort to remove in so far as is humanly possible most of the errors inherent in photography, so that the photographs when delivered to the map compiler are the best obtainable under any conditions.

The U. S. Geological Survey and Department of Agriculture are the largest buyers of aerial survey services in peacetime, and since the basic accuracy of the aerial photograph depends on the camera, these two agencies are very careful to specify the characteristics of the cameras to be used in their work.

The following paragraph from Specification D of the Department of Agriculture specifications is given as an example of what is expected in aerial-camera manufacture:

"In order to secure the widest range of competition from manufacturers of, and dealers in, aerial precision cameras, and to insure that photography procured under contract, or directly, is of such a high degree of accuracy as to make it suitable for stereophotogrammetric plotting of topography, these specifications are written."

And to further safeguard against unsatisfactory equipment, the general specifications end with this statement:

"All precision cameras made in accordance with these specifications shall be submitted to the National Bureau of Standards for test before field use under contract, or before purchase, and must be accompanied by a certificate therefrom that it complies herewith."

Multiple-lens cameras have not come in for any discussion in this paper. They are fast becoming obsolete, but it is interesting to know that they were designed to give more photographic coverage in a set of exposures. The first such camera was a 3-chamber affair with a single magazine. This was superseded by the 4-lens camera, developed from a 3-lens camera by adding an extra chamber and magazine directly behind the vertical chamber. In 1930, the 5-lens camera was designed and much mapping was done with this instrument. The 5-lens camera has 1 vertical and 4 oblique chambers, each with detachable magazines. The 9-lens camera was developed by the U. S. Coast and Geodetic Survey for coastal charting. It is so large that a special hoist is used to install it in an airplane.

It is true that developments in aerial cameras and aerial photography as a result of the recent war are of a startling nature. Some were spurred on by demands for a certain type of military operation, and have no future in peacetime applications. Others concerning lenses, filters, shutters, and film will find useful application. The use of color photography for interpretation work, infrared film, lens heaters, and new ceiling heights for transporting carriers, will all have a certain effect on the trend of aerial-camera design. Radar and the application of remote-controlled operation surely will affect the operating mechanism and over-all size of camera.

The discovery of new lightweight material and the application of invar steel will have important bearing on the weight of the camera and the expansion and contraction of the component parts of the frame, thus relieving stress and strain in the entire camera.

It has definitely been established by a recent inspection of European aerial-camera manufacturing plants, that the United States has far surpassed all others in aerial-camera research and application. Research is now being carried out on certain camera accessories that will materially improve the results of aerial photography. The most important of these is the automatic camera mount.

A satisfactory method of mounting the camera in the airplane has not as yet been found, and hence many errors not of a photographic nature occur through inability of the operator to accurately orient his camera for any condition of the airplane.

The function of any camera mount is:

1 To provide an adequate lightweight structural support for the camera.

2 To insulate the camera from airplane vibration.

3 To provide a means for leveling and making azimuth adjustments.

Most camera mounts have met this demand in part, but not to the extent desired for precision work. Undoubtedly camera-mount design will continue to advance throughout the years. Research work on the absorption of torsional or oscillating vibration combined with lateral and vertical motion must be carried on. The application of photoelectric cells for instantaneously correcting tip or tilt of the camera will include the application of some method to speed up the action of the leveling bubble to keep up with the leveling mechanism. It is the general opinion of those so engaged that a proportionately larger share of design effort applied to camera-mount problems will result in greatly improved over-all accuracy and performance on aerial mapping projects.

What the future holds for this new method of obtaining engineering data no one can say. The future depends on the amount of research data collected by the armed services on methods and equipment that are co-ordinated and combined with present civilian research.

We who are engaged in such manufacturing are hopeful and are anticipating a bright and interesting future. The end result will be to approach the accuracy of precision ground-survey methods, not to supplant them, but to be able to combine both to produce a better map at a lower expenditure of engineering dollars.

MOBILIZATION *of the* AIRCRAFT INDUSTRY

Planning to Maintain Industry in a State of Readiness for War

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IN THE period between the first and second world wars there was a great deal of talk in America about preparedness; a great deal of talk and very little action. There was considerable use of the word mobilization; in fact, there were even plans for an M-Day and a series of M-Days, although these plans, in so far as industry knows, were put in a pigeonhole somewhere and forgotten.

The true concept of mobilization, an integration of military mobilization on the one hand and industrial mobilization on the other, had not crystallized in our national thinking until World War II was actually upon us. That concept is clear enough now, and it is evident to every American who is interested in the security of his country that we are faced with the necessity for industrial planning for future emergencies just as much as we are with strategic and tactical military and naval planning.

General of the Army Dwight Eisenhower dwelt upon this fact when he recently stated: "National security is a state of organized readiness to meet external aggression by a quick and effective mobilization of public opinion, trained men, proved weapons, and essential industries, integrated into the most efficient instrument of armed defense, and reinforced by the support of every citizen. The security establishment comprises all the people, all our enterprises, all our Government."

This paper will present industrial mobilization from the aircraft-industry side of the picture.

PLANNING INDUSTRIAL MOBILIZATION IN TIMES OF PEACE

Industrial mobilization must implement war plans. In times of peace, war planning is one of the highest functions of our armed forces. It can therefore be taken for granted that our professional military, naval, and air leaders will have formulated their plans for any given emergency under the stimulus of political and military intelligence.

For industry, war planning means the setting up of the necessary types and quantities of materiel to be procured. These involve on the part of industry, plans for raw material, plans for facilities, tools, and manpower, plans for co-ordination among many different companies and agencies. Then, after the integration of these many factors and the consummation of production efforts, the end products of industrial mobilization become the finished products for war.

When it is stated that industrial mobilization should implement war plans, it is not meant that industrial planning should follow along behind war planning in a subordinate or leisurely fashion. War planning and industrial planning are co-equal members of the same team. It is true that the military is the quarterback and must call the play, but industry must carry the ball. The two must work together every second and both must know the score at all times. It will never again be sufficient for industry to find out at some convenient later date what the score is and how many minutes are left to play—by that time the ball game will be all over.

General Carl Spaatz recently stated in "The Future of the Army Air Forces" that "military doctrines must be continually altered to conform to and take full advantage of scientific discoveries and developments. Industrial planning is similarly important. To insure a maximum production of weapons in a minimum period of time, production to meet any contingency must be planned in advance. This is especially true of military aircraft and its related components which cannot be stockpiled because they become obsolete quickly in this era of rapid technical advancement. The high operational mobility of the Air Forces must be matched always by a corresponding logistical mobility. Unless that is attained, the attainment of operational mobility is nullified."

Before discussing how to effectuate industrial mobilization in a possible future national emergency, let us first review the history of our industrial effort in the light of the political and military background both immediately before and during World War II.

AIRCRAFT INDUSTRY'S WAR EXPERIENCE

Military authorities have indicated that our industrial planning prior to World War II was rudimentary; and so it was. Let us turn to Fig. 1, which shows the production activity in terms of airframe output in millions of pounds per quarter. This serves as our index of production for the aircraft industry.

In retrospect, let us recall that the aircraft industry in 1937 was 44th in size, according to U. S. Census figures, and during the war grew to be the largest industry in the world by the year 1944. It increased 102 times in size. This information is from the report of W. Stuart Symington, Surplus Property Administrator, to Congress in January, 1946. Mr. Symington is now Assistant Secretary of War for Air.

Fig. 1 shows the relation between war events that not only served to bring on the war, but which occurred during the war and which profoundly influenced our aircraft industry's war mobilization. While the chart begins with the year 1937, it can be stated that the aircraft industry in the United States was on the order of a $70,000,000 per year industry from 1930 to 1937.

The political events of 1938, the year of Munich, and 1939, the first year of the war, are still fresh in the minds of nearly all of us.

While there was a strong feeling of isolationism on the American political scene, it was nevertheless evident to a large segment of our population that another world war was a serious possibility. However, Fig. 1 does not reflect it, and had it not been for unexpected foreign orders, the low level of

Contributed by the Aviation Division and presented at a meeting of that Division, Los Angeles, Calif., June 3–5, 1946, and at the Semi-Annual Meeting, Detroit, Mich., June 17–20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

production activity in the aircraft industry actually would have declined during this period.

Testimony given under the Walsh-Healy Bill, to the Department of Labor, by the aircraft industry in 1938, indicated a total employment of only 33,000 persons in February of that year. It should be pointed out that from this small group was to be drawn the technical leadership for over 2,000,000 persons employed by this industry in 1944. In our wildest dreams, we who were in the industry at that time never conceived of an industrial mobilization effort of such proportions. We had no hint of such requirements from the armed services, nor did we make any plans at that time for such a war emergency. This should be kept in mind in interpreting the growth as reflected in Fig. 1 and Fig. 2.

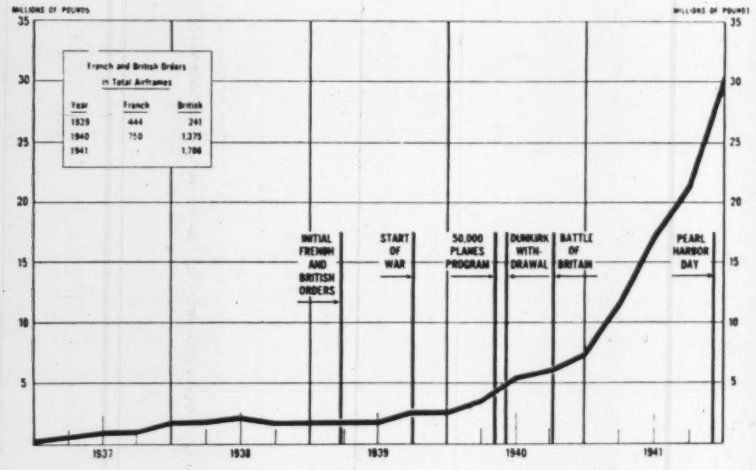

FIG. 1 AIRCRAFT PRODUCTION PRIOR TO WORLD WAR II

(In terms of airframe weight, excluding maintenance spares. Quarterly including French and British orders. Source: Office of Plans and Policies, Army Air Force.)

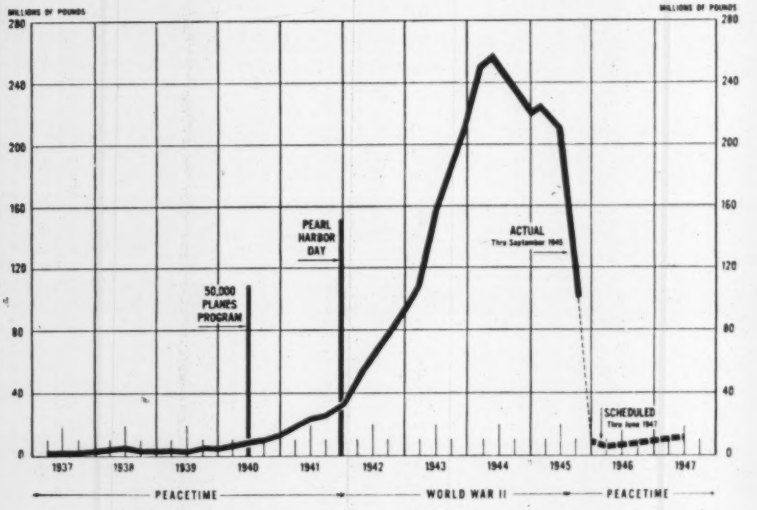

FIG. 2 AIRCRAFT PRODUCTION IN WORLD WAR II

(In terms of airframe weight, excluding maintenance spares, Quarterly.)

However, the French and the British, who were closer to the coming European events, sent missions to the United States which resulted in placing substantial contracts in the order of $100,000,000, in March, 1939, as noted in Fig. 1. These were the orders that actually prevented unemployment in the American aircraft industry owing to the low volume of procurement for our own military services at that time. The roughly 50 per cent increase in production shown by the chart at the start of the war in September, 1939, was almost entirely the result of these and subsequent orders. Fortunately, this required an expansion of floor space and facilities by certain of the companies who were given these foreign orders, and forced such companies to give thought to further expansion for their own production, in the event this country became involved.

As the further orders from France and Britain followed, the curve again sweeps upward to the period of Dunkirk, as noted on the chart. Dunkirk, it will be recalled, marked the finish of an effective war effort by armies on the Continent, accompanying the collapse of France and the Low Countries. Coincidentally, our President announced the 50,000-plane production program.

Certainly it can be said that no one in the aircraft industry had ever contemplated such production of aircraft. There followed the Battle of Britain, entirely a battle in the air. Many current historians feel this to be the turning point of the war. The American aircraft industry was not in a position to give any material help to the courageous British who fought and won their battle by the fall of 1940, standing alone.

Yet the fate of the war hung on the outcome of this critical period. Should another war be fought, it may be our fate that will hang on just such a battle. It is only fair to ask the question, with a thought to the future, as to whether this great nation ever wishes to be caught as industrially unprepared should a future emergency materialize.

Thus in a practical sense our industrial mobilization in the aircraft industry for World War II really began with the collapse of France, the withdrawal from Dunkirk, and the announcement of the 50,000-plane program by our President, nine months after the start of the war.

By Pearl Harbor Day, on December 7, 1941, when we were the victims of a surprise attack, our total production in terms of such a major war was still insignificant (reference is made to Fig. 2).

The year 1942, while showing a tremendous percentage increase in production, amounting to approximately threefold for the year, was, from a military point of view, a year of acute shortage of airplanes on all combat fronts. This was the period of "filling up the pipe line." We hit our stride two years later in 1944 and from there on were outproducing the world, having demonstrated America's vast resources in manpower, industrial capacity, and technical genius for production.

This, then, is the picture that we must have in mind in considering what we should do when looking toward the future.

SIX YEARS REQUIRED TO MOBILIZE

Assuming that the world events of 1938 indicated the necessity for urgent industrial mobilization under any efficient system of competent world-wide military and political intelligence, we did not reach our peak in production until 1944. This consumed a period of six years.

This paper will not discuss the rapidly changing character of air warfare, with its new concepts of strategical long-range

striking force, and the coming warfare of long-range missiles and pilotless aircraft. Nevertheless, it is reasonable to conclude that should a future war emergency arise, Atlantic Ocean and Pacific Ocean barriers would probably never again provide us with such a span of years in which to put our national production machine to work. Therefore the methods which we in industry used to bring about the results graphically portrayed in Figs. 1 and 2, must be discarded in favor of more orderly and efficient procedures. Six years from threat of war to peak production would never do should there be a World War III.

As engineers, let us turn to some of the underlying fundamental considerations with which we technicians must deal. For example, let us examine the period of development of the Boeing B-29 Superfortress. This very heavy bomber, which was a logical development of its predecessor, the B-17 Flying Fortress, required eight years from inception to combat, or a period longer than the entire war, by several years.

Summarizing the B-29 development, there were eleven major design studies before it was committed to metal. The wind-tunnel tests had to be evaluated before the prototype could be constructed. Prototype and static test articles had to be finished in metal, after which flying tests had to be conducted and translated into further engineering changes. The engineering changes in turn brought forth further production models. Accompanying all this was elaborate production engineering and tool design. Finally the plane had to be refined through service tests and preliminary combat experience. Only then was it a combat airplane.

It is a fact that we used no combat airplanes in World War II that did not have their beginnings in the period before the war. From this we conclude that one of the primary considerations in industrial mobilization is that of continued research and development, with sufficient production to provide the military services with test quantities large enough in number to organize combat units, such as squadrons or groups, capable of carrying out simulated war maneuvers.

As a corollary of this statement, it should be clear that harnessing the might of our great mass-production industries and of the vast quantities of subcontractors, can serve only to increase production and cannot shorten, or contribute to shortening, this fundamental period of development required for modern combat aircraft. Robert A. Lovett, formerly Assistant Secretary of War for Air, reported to the Senate in 1945 that the aircraft industry itself produced 90 per cent of the airframes used in the recent war, which means the mass-production industries produced the other 10 per cent.

ENGINEERING RESOURCES REQUIRED IN AIRCRAFT PRODUCTION

Let us consider the kinds and types of engineering resources needed in the production of aircraft. While aircraft design represents only $7\frac{1}{2}$ per cent of the total engineering effort, it represents a body of engineers whose professional experience is so specialized and of such a high order that they cannot be trained in time of emergency and must necessarily be part of the peacetime aircraft industrial establishment.

Much of what has just been said applies to those who are engaged in completing the prototype and in the flight-test evaluation, which, taken together with design engineering, constitutes 20 per cent of the total engineering effort. Engineering changes and production engineering, representing 15 per cent and 40 per cent, respectively, of the total effort, can draw on other ranks of engineers to swell the working forces. Similarly, tool development, accounting for the remaining 25 per cent, can draw heavily from the high-production industries. Nevertheless, all of these engineering activities are peculiar to aircraft engineering, and a period of indoctrination to take care of this requirement must be provided in our industrial-mobilization planning.

One of the mistakes made in the recent war, which we should not repeat in any future emergency, is that of inducting aeronautical engineers and technicians into the armed services. This created one of the most difficult problems to be faced by aircraft manufacturers during the war. This is entirely aside from the injury to the nation's economy now being experienced through what has been estimated as the shortage of 75,000 trained engineers, because engineering students undergoing technical training in the schools and colleges were taken for military service. The right of the military services to draw from factory or office personnel cannot be questioned, providing the highly trained and irreplaceable technicians for whom substitutes cannot be trained in time to meet the war needs are not requisitioned.

A necessary part of any future planning should be a study of the supply of suitable engineering talent and preparation of plans for refresher courses and accelerated courses in educational institutions to meet the emergency needs. The ability of women, who were taught the simpler forms of drafting and engineering in such accelerated courses, is an indication of what can be accomplished.

GOVERNMENT AND INDUSTRIAL RESEARCH

The relation of government laboratory research and evaluation to that of applied research or development, which is the normal function of industry in our country, is of particular interest. It can be simply stated that broad basic research can often best be accomplished in government laboratories, built and operated with public funds, supplemented by university facilities and some private laboratories. Likewise the application of the resulting scientific data can best be accomplished by competitive conditions in private industry, responsible for the development of a finished article to meet government specifications. Finally, the laboratories and proving grounds of the armed services can best evaluate the technical performance of the developed articles and adapt them to the techniques of combat conditions, resulting in newer and improved specifications for aircraft.

This process should be a continuous one, and all those who contribute to it should be a part of the peacetime establishment, without which no nation can hope to remain a first-rate war power. There need be no overlapping or clash between private enterprise and government efforts if these simple fundamentals are kept in mind.

It is interesting to review the testimony of Dr. Albert Speer, the Minister of Armaments and War Production in the German Reich, who pointed out that even in a totalitarian state, industry could competitively perform the development functions only when independent of bureaucratic interference, and that even where the German government had direct ownership in such industries, it nevertheless left the management in private hands. The testimony of Dr. Speer, taken in August, 1945, by the Office of Military Government for Germany, may be found in Report No. 40, issued by the Director of Intelligence of the Field Information Agency, Technical.

AIRCRAFT PRODUCTION FOR VICTORY

The pattern for victory in the air during the recent war may be deduced from the figures which follow. From their consideration, another phase of industrial planning becomes apparent. Between the years 1941 and 1944, fighters increased in weight by large increments annually, from 3600 lb average airframe weight, to 5560 lb average airframe weight. Similarly, bombers in the same period increased from 9870 lb airframe weight to 17,470 lb airframe weight. Even trainers

showed 10 per cent increments per year through 1943, after which trainer manufacturing was largely discontinued as the training needs were being met. These figures reflect the rapid changes in size of aircraft, from which we can deduce the rapid rate of obsolescence that was occurring. This should sound a definite note of warning to those who believe that tools and designs can be frozen in order to bring about higher rates of production and more completely mechanized tooling. Such theories were tried in our industry and were found to be impractical in World War II.

A study of the time required from the start of engineering of new types of aircraft and engines or major modifications of them to their production peak under wartime conditions is highly enlightening. For Class 1 aircraft, a 10,000-lb single-engine type, a period of two years is required to carry it through the work-up stage and first flight tests, to its production peak. For Class 2 aircraft of 10,000 to 25,000 lb, equipped with twin engines, approximately three years are required from engineering to production. Four-engined planes of more than 25,000 lb require $4^1/_2$ years. In the case of an aircraft engine, nearly four years are required to bring it to production: assembly of the first engine in about one year; 150-hr test completed during the second year; production of about 25 units per month during the third year; and attainment of peak production in the fourth year. In so far as the author knows, no successful aircraft engine of tactical importance has ever been perfected for combat use in less than five years.

It should be noted that while we have discussed airframes, the engine example should serve to bring out the fact that similar characteristics are to be found in the development of instruments, accessories, and larger functional components of aircraft. Even the propellers for our large planes, simple as they may appear to those without engineering training, require a long time to develop. One of the leading propellers has been under development for five years and was not perfected by the end of the war.

MAJOR CONSIDERATIONS IN INDUSTRIAL MOBILIZATION

With these fundamentals in mind, we are now in a position to summarize the major factors influencing industrial mobilization and to set forth our conclusions from past experience and a study of the factors involved:

1 We have never had true industrial planning and mobilization in the United States.

2 Without industrial planning and mobilization, it is questionable whether we can remain an important military factor in any future world emergency.

3 It was our good fortune in two world wars to be given time in which to mobilize the industrial might of America while our allies fought the enemy. Modern concepts of air warfare make it extremely doubtful that we would ever have a third opportunity of this character.

4 Industrial planning and mobilization must be carried on in peacetime if it is to be effective in wartime. It is a specialized technique and engineers should readily appreciate that it is an ever-changing art, requiring constant practice to be proficient.

5 Industrial planning is merely the next stage after war planning. One without the other can hardly be effective and certainly cannot constitute a comprehensive plan for national defense. Therefore, industrial planning should be on the same level and of the same rank as war planning and both should be continued peacetime activities.

6 Industrial planning presents two important aspects, i.e., the over-all national plan, and the detailed plan for industries and for individual companies.

7 Industrial planning and mobilization must include planning for (*a*) raw materials; (*b*) subcontract facilities; (*c*) manpower; (*d*) production facilities, including space, equipment, and tools. Such plans will vary with the article to be manufactured and will not serve their purpose unless kept up to date.

8 Industrial planning costs money, and the plans should be executed under military specifications and paid for only when competently performed. In order to assure that funds for industrial planning and mobilization will not be used for other purposes, they should be earmarked in the budget and administered by an industrial-planning section of the armed forces.

9 Study of the accomplishments and the mistakes of the past, and the incorporation of new ideas and techniques for the future, should be carried on continuously, jointly by industry and the military services. For this purpose, an Industrial College of the Armed Services should be created to rank with Army and Navy service schools, and industry should be required to grant furloughs to competent key personnel, to be assigned there for courses of study as is now the case for Army and Navy personnel.

10 Too great an emphasis cannot be placed on the necessity for continued research and development. As already outlined, Government and industry should co-operate, each in its specialized field, without duplication or without overlapping of functions.

11 Military planning, research and development planning, and production planning, as three functions, should have the same rank and be co-ordinated at the top level of national defense. Funds for each should be earmarked in departmental budgets.

12 An integrated aircraft industry, engaged in engineering the advanced designs and manufacturing them in combat-test quantities, should be maintained as part of the peacetime military establishment.

CONCLUSION

Recognition of these twelve conclusions is essential if emergency industrial mobilization is to be made effective.

Secretary of War Robert P. Patterson recently announced the creation by the Army of a Research and Development Division as a top-level General Staff organization. Its purpose is to coordinate Army research with the activities of industry. In the announcement of the new division, it was stated that "the Army must have civilian assistance in military planning as well as for the production of weapons; scientists and industrialists must be given the greatest possible freedom to carry out their research."

This is only a step in the proper direction, true, but it is a step, for research and development are the base upon which planning and mobilization must be founded.

This spark of appreciation for one of the fundamental considerations of industrial mobilization, as seen by one of our most distinguished leaders, must be kindled into a lasting flame. General Eisenhower has indicated that "objective interest in our own military affairs never has been a peacetime characteristic of our nation."

It devolves upon the engineering fraternity of this country, to whom the facts presented in this paper have great significance, to see that the habit of peacetime lethargy does not return to our national thinking and planning.

If the full significance of industrial mobilization does not reach the American public, if its import is not stressed by members of this and other engineering societies, we have no real hope of national security now or at any future time.

Fundamentals in

VEHICLE ACOUSTICS

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THIS article is based on 11 years of work with the acoustics of automobiles, particularly applied to the bodies. Inasmuch as it is obvious that airplane noise from engines, propellers, and so on, will be quieted at the source as much as possible, this article deals only with the treatment of bodies, or fuselages in the case of airplanes.

FUNDAMENTALS OF ACOUSTIC TREATMENT

There are three fundamental methods of treatment: sound insulation, panel deadening, and sound absorption. They are quite different approaches to the problem and are named in the order in which they should be used.

Obviously, "sound insulation" is the shutting out of outside noises. "Panel deadening" is the deadening out of noises which are transmitted to the interior of a vehicle by the resonance of the panels. "Sound absorption" is the taking up of the sound which finally arrives within a vehicle.

Sound insulation will not completely stop noises from entering a vehicle body, and to what extent they enter will depend on how many openings there are, and how many resonant panels there are to pump in the noise. The noise level inside the vehicle will build up until it is the same as the noise outside, provided there is no absorption of whatever noise does come in. Sound-absorptive material is the pump which reduces the noise that does enter the vehicle.

Sound Insulation. We are all familiar with sound insulation, and the values of insulation materials are well known, but such materials must also be judged in relation to their properties of resonance. For instance, a 16-gage steel panel of an automobile dash has about the same sound-insulation value as 1 ft of brick wall. Yet this steel is highly resonant, and although little noise on one side of the panel will pass directly through the steel, it may force the panel to vibrate so that the panel generates a similar sound, and often of almost equal intensity on the opposite side of the panel.

Panel Deadening. There is less known about the science of deadening the vibration of panels than about the properties of sound insulation or sound absorption. As a result, many erroneous ideas are prevalent and many materials are used which are not suitable for panel deadening.

The vibration of metal panels in a vehicle is probably not violently objectionable so long as they vibrate at high pitch. Unfortunately, some panels in most vehicles vibrate at low pitches, even below 36 per sec, and these low-frequency noises predominate as a low-pitched rumble. The old physics experiment of two tuning forks vibrating at different pitches illustrates how this panel rumble predominates. If a tuning fork pitched at 1024 and one pitched at 128 cycles per sec are both sounded simultaneously with equal intensity, the sound of the higher pitched fork will disappear as the intensity of the sound dies away, until only the sound of the low-pitched fork is heard. The high-pitched fork is still sounding, but it is masked by the low-pitched one. To prove this, the lower pitched fork may be silenced and the sound of the higher pitched fork will again be heard.

In just the same way, if the low-pitched noises from panel vibration are eliminated, then will be heard the higher pitched noises which were masked before, but which are not so objectionable.

METHODS USED FOR REDUCING NOISE FROM PANEL VIBRATION

There are four methods available for reducing noises of vibrating panels: (1) By mass change; (2) by elasticity change; (3) by nodal change; (4) by actual absorption of vibration.

Mass Change. This is a common method used today, and consists in weighting the panel so that its natural period of frequency is changed, in the hope that the new frequency will be such that it will not be resonant. This is often effective, although it is a haphazard method, because the increasing of the mass of a panel results in lowering its natural period of vibration so that if it is resonant, the sound will be of a lower pitch. It is possible for the new increased mass to be just right, so that the panel becomes more resonant than before, but at a lower and more objectionable pitch.

In the past, the materials used to accomplish a mass change were sprayed-on asphaltic material or some sort of soft thick paper. The sprayed-on method has a big advantage of being the cheapest way of changing the mass. It has, however, the disadvantage of being dependent on the human factor, since a workman will put on varying amounts of asphalt depending on the pressure of work. It is of course not suited to treatment of metal floors, since it can be readily chipped or knocked out of place. It also has the disadvantage of presenting a rough unfinished-looking surface. Its added weight makes it impractical for airplane use.

Its greatest disadvantage as a deadener is that the correct consistency of asphalt, to be stiff enough in summer so that it will not flow, will be so hard and stiff in winter that some of its effectiveness (lack of elasticity) is lost.

A different method of changing the mass is by use of some sheet material which is cemented to the resonant panels. The gain from sheet material, such as an asphalted felt, is that the amount of deadener is determined beforehand by its thickness, and does not depend on the workman; also, it may be of a smoother surface, both from an appearance standpoint, and to prevent the lodging of dirt. Moreover, felt will retain a much softer asphalt than it is possible to apply by the spray-on process, hence the deadener will not be so hard and ineffective in cold weather.

There are surprising misconceptions of the value of different materials now being used, and scientific tests are showing that some materials, supposedly good panel deadeners, may actually increase the resonance of the panels they are intended to deaden. This is particularly true of building boards, which can be more resonant than the panel itself. Building boards are often used on the floor of vehicles, partly because of their excellent heat- and sound-insulation values. Unfortunately, the floor panels

Contributed by the Aviation Division and presented at the Semi-Annual Meeting, Detroit, Mich., June 17–20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

of an automobile are often so irregular that a building board, because of its rigidity, cannot be in contact over the entire surface of the floor and must be attached by bolts. This further increases the resonant possibility of a board as contrasted with the use of flexible sheet materials which can be glued to the floor and will more or less conform to irregularities in the plane of the floor.

Elasticity Change. If the elasticity of a vibrating panel is changed, its period of vibration will be changed. It is probably because of low elasticity that the all-aluminum body of the past did not have the panel rumbles of modern steel bodies.

The addition of a viscous inelastic material to a steel panel makes a new unit (steel and viscous material) whose elasticity is much less than the elasticity of steel. The viscous inelastic properties of asphalt, as well as its weight and low cost, have made asphalt the leading material for deadening today.

Nodal Change. The nodal principle of changing panel vibration consists in setting up nodal lines in the vibrating panel so that the panel does not vibrate as a whole, but in several sections; the smaller the section, the higher the frequency of its vibration.

If a string is vibrating as a whole, and a finger or other damping means is placed on the center, the string will cease to vibrate as a whole, but will vibrate in two sections on either side of the finger. The nonvibrating point where the contacts are made is called a nodal point, and the two separate vibrating sections (if they are one half the length of the string) will be vibrating at twice the speed of the undamped string, or at twice as high a pitch. It is the use of a finger sliding on the strings of a violin and changing the length of the vibrating portion which gives the string its higher or lower pitches.

Notice that panel damping by nodal change is the reverse of the method of handling panel vibration by a mass change. Increasing the mass of a panel reduces the pitch of its vibration, whereas by the nodal method the pitch of vibration is increased, presumably up to a point where it is unobjectionable, or may be more efficiently handled by sound-absorbing materials which are much more effective in taking care of high-pitched sounds.

The embossing of ribs in a floor panel tends to break up the vibration of a panel as a whole by this nodal method; the stiffening of the ribs forming nodal lines. Practically, the ribbing of a floor seems to be of little benefit, since the vibrations are often too intense to be affected by such nodal lines, and even a passenger may stand on a vibrating floor panel and still feel the vibration in spite of his added weight.

An example of panel deadening by the nodal method is illustrated in the method used by one automobile company of mounting a steel brace against the door panel, so that the brace against the door panel sets up a nodal line to change its frequency of vibration.

Pacific panel deadener uses two methods simultaneously, i.e., actual vibration absorption and nodal change. This deadener is unique in that it departs from the conventional methods of mass or elasticity change, and accomplishes superior results with less weight.

Essentially, the Pacific deadener consists of sheets of material stitched together, the weight and proportions of the sheets being carefully chosen so that when they are forced to vibrate with the panel, they will vibrate out of phase with it, and absorb the energy of vibration; just as a child in a swing can "pump" the swing against its movement and stop it. This is vibration absorption.

In addition, the stitching of the sheets results in the vibrations of the panel being communicated to the deadener only through the lines of stitching. The result is that this vibration absorption is being effected mainly along the stitch lines. Thus close nodal lines are set up over the whole panel.

A stroboscopic study of the Pacific deadener shows clearly this out-of-phase absorption vibration. This deadener is more effective than asphaltic deadeners of twice the weight. It is suitable for roofs or vertical panels not for floors where the papers cannot hang apart.

Actual Absorption of Vibration. The actual absorption of the energy of the vibration of a panel is theoretically the best way to eliminate the noise of it.

An example of such absorption is an experiment by the Hudson Motor Car Company, in which a piece of steel shafting about 4 in. diam, and about 1 in. thick was laid on the center of a resonant panel. The disk of shafting was enclosed in a felt-lined metal box which was welded to the panel; the box being of such size that the disk laid loosely on the panel. When the panel vibrated, it carried the disk with it as it vibrated upward; the disk, not being fastened directly to the panel, would descend only by gravity as the panel vibrated downward. The pull of gravity being slower in its action than the speed of vibration of most panels, the disk did not descend as fast as the panel vibrated, hence the mass of the descending disk met the upward moving panel as it vibrated, and damped the vibration by taking up its energy in the heat of impact. This experiment was effective in deadening the panel. It was not a practical method, both because of cost, and because of the difficulty of mounting the disk so that it was free in its movements within the box, yet sufficiently cushioned so that it would not chatter.

Another attempt actually to absorb the energy of vibration was by the use of a sheet of uncured rubber cemented to a panel. Rubber has the property of hysteresis which may be defined as "a lagging of effect when forces acting on a body are changed, as if from viscosity or internal friction." In other words, the movement of a piece of rubber sets up internal friction. This may be demonstrated by stretching a heavy elastic band at a fast rate for 10 sec. The rubber will grow appreciably warm. Rubber has the further advantage of being relatively inelastic (in the true physical sense where ivory is the most elastic substance), also, its density gives it a mass which is beneficial. Actual tests of such a rubber panel deadener do not show the results one might expect. This may possibly be because the rubber is not sufficiently uncured. Rubber is also a relatively expensive material.

A third way of absorbing the vibration of a panel is through the use of fibers mounted on end to a heavy backing sheet, so that they stand at right angles to the plane of the panel. Just how such fibers absorb vibration is uncertain, but it is probable that when they are fastened to a heavy backing sheet such as an asphalt felt, the groups of fibers buckle and yield to the vibration of the panel because their resistance is less than the inertia of the heavy backing sheet. This is the principle used in the panel deadener used on the floor of the Lincoln Zephyr in which jute fibers are needled through an asphalted sheet. The needling forms tiny tufts of jute on the outside of the asphalt, and these fibers stand at an angle to the plane of the panel.

METHODS OF TESTING

A common method of testing the improvement effected by a panel deadener, where it is applied to a door of a vehicle, is by slamming the door and noting the sound. By proper panel deadening, a slammed door sounds as though the door were of very heavy construction. This test is of real value because the noise of a door slam is often judged by a buyer to indicate the grade of construction of the body. However, a door may sound very dead when slammed, yet the panel of the same door may be very noisy when the vehicle is in motion. This is because the vibration set up by slamming the door may be such

that the panel has no resonance at that particular pitch, yet when the vehicle is moving there may be vibrations forced on the door panel to which it is resonant. Therefore it is unsafe to judge that a door panel has been adequately damped just because it sounds dead when it is slammed.

In the past it has been common for a salesman of a panel-deadening material to demonstrate its effectiveness by suspending by strings two circular disks of metal, one of which will be bare, and the other will be treated with the panel deadener being demonstrated. By rapping both panels with his knuckles a surprising difference in the noises of the two panels will be demonstrated—the treated panel will make a low "bong" noise and the untreated panel will be very tinny.

Scientific knowledge of panel vibrations shows how incomplete is the demonstration of the bong test. Its weakness is similar to that of the door-slamming test, in that the vibration impressed on the panel by rapping it with one's knuckles is probably only of one frequency, and even that frequency may not be the one at which the panel vibrates when in a vehicle. It is surprising how effective a demonstration can be made by the bong method, using materials which are actually of small value as panel deadeners.

From the bong method has evolved the method of vibrating the panel by letting a string-suspended ball swing from a predetermined height so that it strikes a uniform blow on both panels to be tested. It has the same weaknesses as the bong test, except that the intensities of comparative blows are uniform.

A more modern and scientific method of testing panel vibration is by mounting the panel with its periphery clamped down, and forcing it to vibrate by an electromagnet. The speed of magnetic vibration may be controlled so that different frequencies may be forced on the panel. (Note that in scientific methods of testing panels the periphery is best clamped down. This is primarily because the only formulas for panel vibration have been worked out with the clamped plate. Even Lord Rayleigh has thrown up his hands when it comes to formulating the action of a panel whose periphery is not restrained. In addition, it is best to test a panel in this way because the panels used in vehicles are invariably fastened down around their edges.) A microphone pickup is usually used in connection with this equipment, and the noise emitted by the vibrating panel is picked up and transmitted to a galvanometer or other recording means so that an accurate comparison may be made of how the panel vibrates under different conditions.

This method is subject to two criticisms: The first one is the question of whether or not the tones emitted by the panel are pure tones or mixed. If they are the latter, then an analysis of the effectiveness of a panel deadener for different frequencies becomes more difficult. The second objection is that this equipment does not seem suited for testing a panel deadener which uses the principle of nodal effects to change the frequencies of vibration. If, for instance, it were desired to test a felt which had been impregnated with a plaid of asphalt stripes, then it would probably make a considerable difference where the center of the magnet was located in relation to these nodal lines, i.e., the forced vibration being centered on one of these squares will probably vibrate the panel more intensely than if the center of magnetization came directly on a nodal line.

Using the magnetic-vibration method over a square plate which is clamped only at the corners is quite a doubtful method of procedure. It is questionable whether a square plate clamped at the corners will vibrate the same as a plate clamped all around its edge; and it is probable that entirely different nodal patterns will be set up.

The use of the magnetic-vibration method without a microphone pickup so that the comparative sounds are judged only by ear, is unscientific, and can give results of doubtful accuracy. Its weakness lies in the inability of the ear to give an accurate determination of difference in noise levels so that it cannot closely judge a resonant frequency.

A test method has been evolved by Dr. Geiger at Ann Arbor which seems to eliminate the weaknesses of the foregoing methods. It consists in making the panel vibrate by air-borne sounds whose frequency and intensity can be controlled. In this method, the test panel is the lid of a brick box, inside of which is a source of sound supplied and controlled by an oscillator whose frequency may be varied. The noise of the resonant panel is picked up as in other methods by a microphone connected to a galvanometer, etc. The chief advantage of this method is that it tests all types of panel deadening equally well, even nodal panel deadeners.

With either the magnetic or the air-borne vibrations, it is necessary to use a diameter of panel which is resonant. It has been found that if 19-gage steel is used, 16 in. diameter, it will be sharply resonant over many frequencies. This characteristic of a vibrating panel being resonant in many frequencies is one of the surprising discoveries of recent investigation.

In any method of testing it is important that the metal plate be permanently mounted. If the plate should be removed, it cannot be remounted with exactly the same tension or in exactly the same position, and will not respond the same as before it was changed.

A word of caution is necessary. In a demonstration of a panel deadener, be sure to notice the amount of adhesive used. Many adhesives, particularly asphalt ones, are in themselves good panel deadeners, hence if enough adhesive is used, even a sheet of newspaper may be demonstrated to be a good damper.

SOUND ABSORPTION

Sound absorption is the final step in quieting a vehicle and should not be taken until both sound insulation and panel deadening have done their utmost to exclude outside noises.

The benefits of sound absorption act on a logarithmic curve and their results are not always as anticipated unless this logarithmic value is understood. Consider the curve of absorption, Fig. 1, which gives the results obtained from a typical absorptive material. On one side are marked off equal units of x sq ft of such material; and on the other side are shown typical decibel reductions accomplished by the material. Notice that the first x sq ft of material accomplish a great reduction in the noise. Notice how the second x sq ft accomplish less reduction, and the reduction continues to be less for each additional x sq ft.

Now, the first x sq ft represent the absorptive materials which are already in a vehicle. Such materials are the upholstery, carpets, the cotton batting in the deck, etc., hence this first big reduction has already been achieved, and only lesser reductions can follow thereafter. It will readily be seen that from a fourth or fifth unit of x sq ft the noise reduction would be so small that it would hardly be worth while. This chart represents the reductions accomplished by a material having the absorption of 1 to $1^1/_2$ in. of hair felt. A less efficient absorber would, of course, require a larger number of square feet to achieve the same results.

A body or fuselage engineer who does not appreciate this logarithmic property of a sound absorber will be confused. He knows that a material with 15 per cent absorption costs y cents per sq ft. Hence he expects that another material having twice the absorption, 30 per cent, should cost only twice as much. However, absorption values do not add up arithmetically; they add up logarithmically. At 256 the absorp-

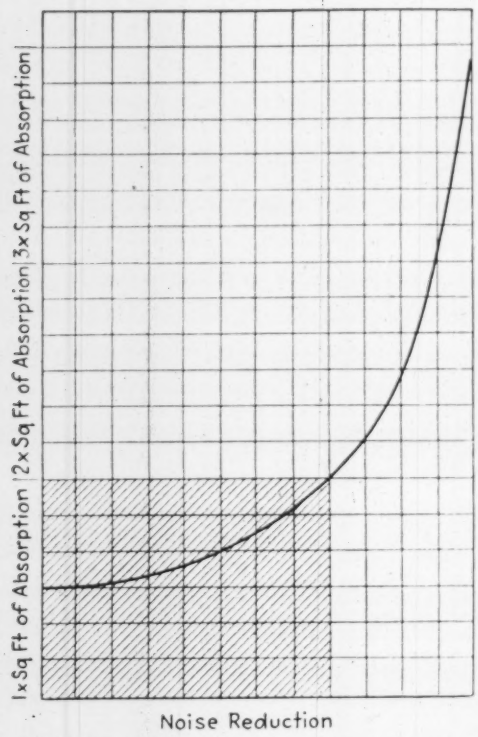

FIG. 1 RESULTS OBTAINED WITH TYPICAL ABSORPTIVE MATERIAL

tion of 15 oz jute is 18 per cent. Twice the weight of felt only increases the absorption to 25 per cent, and 3 times the weight increases it to 27 per cent.

Hence an absorber of double the efficiency of another will generally require several times as much material, and not merely twice as much.

The tautness with which a ceiling covering is mounted has a great influence on the effectiveness of a sound absorber attached to the roof above it. This must be understood in order to explain why completely covering the roof with a good absorber often shows poor results.

The flimsy cloth of most automobile headlinings has relatively small sound-absorbing properties when it is slack. But when the same cloth is stretched tautly, its sound absorption increases. Theoretically, the headlining may become so effective of itself that the benefits of a moderately efficient absorber mounted on the roof above it are lost. It is necessary to use a highly efficient absorber above a taut headlining to obtain results that are worth the added cost of the absorber.

AVAILABLE MATERIALS

To understand the different acoustic materials available for vehicle use, it is necessary to know how they function. If the intangible vibrations of sound waves can be translated into familiar movements, then an understanding becomes easier.

Suppose the energy of a sound wave be compared to that of a thrown ball. To absorb sound is to absorb the energy of its wave, and to stop the ball is to absorb the energy of its motion. If such a ball is thrown through a field of tall grass, each blade of grass which the ball touches takes its little toll from the energy of the ball by friction, until the ball comes to rest. It obviously takes a deep field of grass to do it. This is the principle upon which felt functions to absorb sound.

Similarly if this ball were thrown into a wooden maze in which it was trapped, it would bounce back and forth until its energy was dissipated in heat. Here again, a deep maze would be required to absorb the energy. This is the principle on which certain other sound-absorbing materials function, notably compressed excelsior tiles and the porous acoustical plasters.

Allen Industries made another acoustic material which absorbs sound by a wholly different principle. If a blanket is hung on a clothesline and a ball is thrown against it, the ball will be stopped and in a very small space. The energy of the ball is transferred into making the blanket jump (vibrate in the case of sound), and this jump of the blanket eventually is absorbed as friction. In other words, other materials absorb sound energy by direct friction and take a sizable depth to accomplish it, whereas the Allen material transfers the sound energy first into energy of vibration and then into friction.

Moreover, since the vibrating blanket depends for its function on not letting the ball go through, a sound absorber designed on this principle will be a good sound insulator as well as absorber. Most sound absorbers which function on the principle of absorbing by direct friction (the field of grass) are poor sound insulators. Or if they are compacted by hard-felting they become better insulators, but lose their absorption value. Plate glass has high sound-insulating value, but negligible absorption. Celotex and Masonite boards are materials whose absorption has been sacrificed to build up the insulation values.

If a sound absorber (friction principle, such as a felt) be built up in thickness, it will become a good sound insulator, but the expense and the bulk of such a material make it impractical.

VIBRATION

A great deal of work has been done in the past few years to overcome inaudible vibration of vehicles, yet few designers have taken advantage of the important connection between sound and vibration. It is a well attested fact, often noted by earthquake authorities, that a slight earthquake which is not heard is seldom felt. For instance, if an earthquake shakes a building in which there are two adjoining offices and one office has pictures on the walls or other furnishings which can rattle, the occupants of the room with the pictures will feel the earthquake because they hear it, and the occupants of the adjoining silent room will not even suspect that it has occurred. This phenomenon of joining two senses is similar to the phenomenon of a man's being unable to taste the smoke of his pipe in the dark if he cannot see it.

HOW MUCH CAN BE ACCOMPLISHED

The amount that noise in a vehicle is reduced is measured in terms of its decibel reduction. If a vehicle has a noise level of 50 decibels and by acoustic treatment this is reduced to only 40 decibels, then a 10-decibel reduction has been accomplished.

The question is immediately raised, "How much is 10 decibels? Is it a great difference or a slight change?" The definition of a decibel is of little help and is unsatisfactory for several reasons, mostly because the ear is not uniform in its sensitivity. For instance, a noise reduction of 10 decibels at a low noise level (40 db to 30 db) is much more evident to the ear than a 10-decibel reduction at a higher noise level (70 db to 60 db).

Professors Geiger and Firestone of the University of Michigan have conducted a series of experiments to learn how great a per cent change in sound level was heard for different decibel reductions. These tests determined what the ear registers, not what mathematics or instruments indicate.

From these results has come the following rule: Each decibel of noise reduction is equal to a 6 per cent reduction of the noise. It applies only to the intermediate ranges of noise level, the levels prevalent in vehicles (other than airplanes because higher noise levels make reductions in sound less evident). It is not strictly accurate, but a practical yardstick.

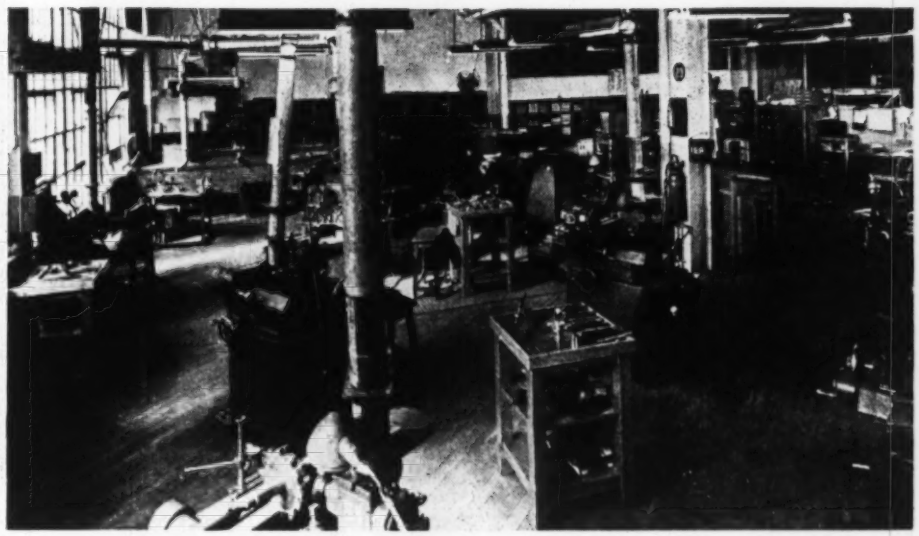

FIG. 1 CENTRAL CARBIDE ROOM WHERE ALL CARBIDE TOOLS ARE MANUFACTURED, GROUND, AND STOCKED FOR THE TOUCH-UP STATIONS

CARBIDE TOOLING *at the* NEW YORK NAVAL SHIPYARD

By C. A. PALMER[1] AND J. G. KENNEY[2]

WHEN, in 1942, the Office of Procurement and Material of the Navy Department directed all naval establishments to make greater use of carbide tools, the New York Naval Shipyard instituted a program for the control of all phases of manufacture and application of these tools. This program was developed by and under the jurisdiction of the Industrial Engineering Section, and served admirably to offset the shortage of high-speed tool steel and to increase production in the shipyard. This increase in production enabled the shipyard to cope with heavier work loads, meet faster established schedules, and in the ordnance shop to clean up a 4-month backlog of work. For many specialized jobs the increase was as high as 300 to 400 per cent, while on production runs the increase was from 100 to 200 per cent.

ORGANIZATION AND FUNCTIONS OF MACHINE SHOPS

To supply adequate reason for the institution of the unusually large carbide-tool program, hereinafter described, a résumé of various types of work performed in the shipyard is necessary.

At the New York Naval Shipyard vessels of all types, ranging from the smallest landing craft to the largest aircraft carriers, are built and repaired. In addition to this tremendous amount of repair and new construction work, many items are manufactured on a production basis and supplied to all naval activities.

Three machine shops, which make wide use of carbide tools are the ordnance machine shop, the inside machine shop, and the central tool shop. The ordnance machine shop is responsible for the manufacture and repair of all ordnance equipment including fire-control instruments, radar equipment, gun directors, gun foundations, and optical instruments. The inside machine shop is responsible for the repair or alteration of all equipment removed from ships during their overhaul period, but not coming under the cognizance of the ordnance machine shop. The central tool shop functions as a service trade for other shops and activities in the yard. This shop is responsible for the maintenance and the care of all machine tools, loose and hand tools, and mechanical equipment, and for the manufacture of jigs, fixtures, and special tools that are not available commercially.

The ordnance machine shop is housed in a modern multistory building with machining facilities on the ground floor for handling all large heavy ordnance equipment. Machine tools located on the other floors in this building consist of approximately 300 lathes, 100 milling machines, 3 planers, 12 boring mills, and other miscellaneous machine tools. Work in this shop more closely approaches production than that in other shops. Tolerance and finish, vitally important on all ordnance work, are satisfactorily obtained with carbide tools.

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[2] Carbide Engineer, New York Naval Shipyard.

Contributed by the Research Committees on Metal Cutting Data and Bibliography and on Cutting Fluids and the Production Engineering Division and presented at the Semi-Annual Meeting, Detroit, Mich., June 17–20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

NOTE: The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

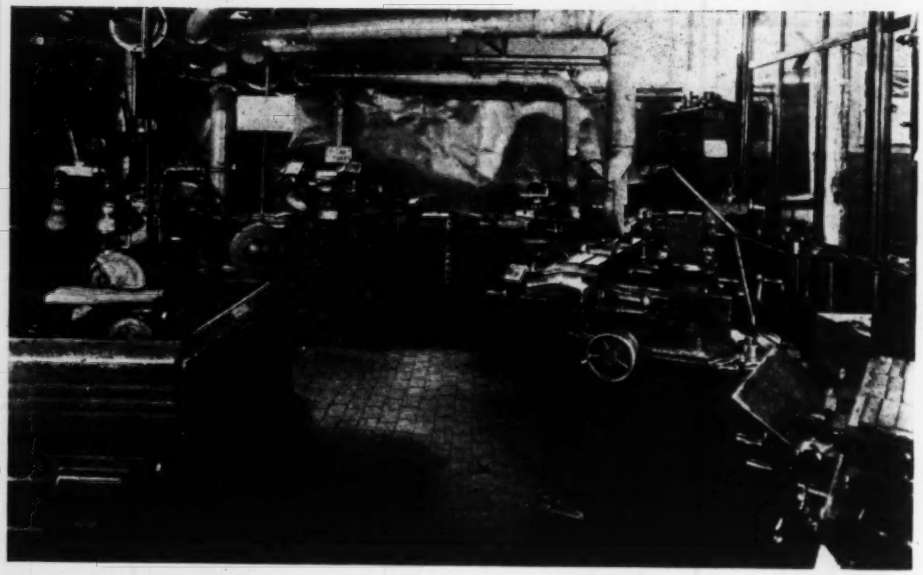

FIG. 2 TYPICAL TOUCH-UP STATION WHERE CARBIDE TOOLS ARE FINISH-GROUND AND STOCKED FOR USE IN A DESIGNATED AREA

The inside machine shop has all types of machine tools located on 8 separate floors of several buildings. These machines include 800 lathes (ranging from the largest, 100 ft long, 36 in. swing, to the smallest toolroom lathe), 350 milling machines of all types, and planers, boring mills, etc.

The central tool shop, the smallest of the three, has fewer machine tools and is centrally located with respect to other shops in the yard. This shop controls the manufacture, grinding, and the issue of tools in the central carbide room.

DEVELOPMENT OF THE PROGRAM

In preparation for promulgating the use of carbide on a large scale, 10 machinists were sent to several industrial plants for short training courses. These courses, given by a carbide-manufacturing company in conjunction with several large production plants, served to provide the men with a basic understanding of carbide and an incentive to develop their uses at the shipyard. These men were then placed in all sections of the shops in order to instruct the machine operators how to apply carbide tools to every type of work. One machinist, who had taken these courses, was assigned to the Industrial Engineering Section to develop and control the yard-wide program. Centrally located touch-up stations were established throughout the yard for regrinding of the tools, and a central carbide toolroom was established to service the touch-up station with tools and to control the stock and distribution. In order to coordinate the work of the central carbide room and the touch-up stations, a delivery system was installed to transport tools between the rooms. At the beginning of each shift, assigned messengers deliver the tools from the central room to the touch-up stations, upon advisement of the touch-up station supervisors.

Central Carbide Room. The function of the central carbide room is to stock and prepare all carbide tools for initial use in the shops. For reasons of economy, the standard single-point tools up to and including $^1/_2$-in. tools are purchased already tipped. Substantial savings in time and money are realized by purchasing carbide tips for all single-point, special, and multiple-point tools over $^1/_2$ in. These tools are then tipped and ground in the central carbide room. Two 14-in. and one 10-in double-cup wheel carbide grinder for single-point grinding, 1 heavy-duty and 1 light-duty vertical milling machine, 1 cylindrical grinder, and 1 chip-breaker grinder make up the equipment used for this work. All brazing is done with acetylene-gas torches at 2 brazing tables; however, an induction heating unit will soon replace this method. A dust-and-fume exhaust system services all grinders and the brazing tables. The central carbide room is illustrated in Fig. 1.

In the central carbide room, shank material is cut to length, the relief and rake angles are milled with carbide tools, the pocket is recessed to tip shape with carbide milling cutters, and the tips are silver-soldered to the shank. Silver solder is the brazing material for all grades of carbide, and on steel-cutting grades and tips over $^3/_4$ in. in length, constantan is added as an expansion equalizer. The tools are then rough-ground on

TO BE POSTED AT MACHINE DURING USE AND RETURNED TO APPLICATION MAN.

CARBIDE APPLICATION CARD

PRINT

~~Machine~~ No. 346482 Pc 7 Job HOUSINGS

Material STEEL MW 3½ RD Date JUL 30 1945

No	SEQUENCE	Dia.	D. Of Cut	R.P.M.	Feed	Stop	Clip	Tool No.	S.F.M.	REMARKS
1	SPOT DRILL	—	—	—	—	HEX	TUR	H.S. DRILL	—	
	DRILL	1 3/32	39/64	187	.011	HEX	TUR	H.S. DRILL	95	
2	REAM	1 1/4	1/64	55	.037	HEX	TUR	H.S. REAMER	20	
	TURN	3"	1/4	460	.011	1	1	788-T410	420	
3	TURN	2 1/8	7/32	460	.011	2	2	788-T410	360	
4	TURN	1 3/4	3/16	460	.011	3	3	788-45° RH	260	
5	FACE	3"	1/16	460	.073	4	4	788-T15	360	
6	FACE	1 3/4	1/16	460	.073	5	—	788-T15	230	
7	PART	3"	1/4	134	.0022	6	—	COT	110	

Disciplinary Action Will Be Taken Against Anyone Grinding A Carbide Tool Without Proper Authority.

DO NOT HANDLE CARD IF IN DOUBT ASK YOUR APPLICATION MAN

HYD-493 Carbide Tools Must Be Returned To Tool Room As Soon As Job Is Completed.

FIG. 3 CARBIDE APPLICATION CARD

14-in. silicon wheels, and finish-ground on 6-in. diamond wheels. After finishing, the tools are held in stock until drawn out by the touch-up stations.

Touch-Up Stations. Carbide touch-up stations, in the ordnance and inside machine shops, are located to service a definite area. Their location is governed by the extent of carbide application in a given area and the size and location of the shop section. For example, in the inside machine shop, one station services a relatively small area containing 135 turret lathes where 95 per cent of all tooling is with carbides; while another station services 3 floors where 75 per cent of all tooling is with carbides. In all, 5 touch-up stations satisfy the needs of the 2 production repair shops. All special tools used in the designated area and all standard tools required for a 24-hr period are stocked in the touch-up stations. Finish-grinding, which removes less than $^1/_{16}$ in. of stock, is performed in the touch-up stations, while tools requiring more than $^1/_{16}$-in. stock removal are returned to the central carbide room for rough- and finish-grinding. Spare milling cutters for those being used in the section or cutters expected to be used during the 24-hr period, are held in the touch-up station. Equipment maintained in the touch-up station depends upon the needs of the area serviced by each station, For instance, the turret-lathe touch-up station, shown in Fig. 2, has the following equipment: two 10-in. aluminum-oxide bench grinders for grinding the steel shanks, two 10-in. silicon-cup wheel grinders (one wet and one dry) for rough-grinding the carbide tools, one 6-in. diamond wheel for finish-grinding the carbide tools, one chip-breaker grinder with a diamond wheel for grinding chip breakers, and two cutter grinders equipped with diamond wheels for grinding special carbide tools. Another section, containing a variety of machine tools, but where carbides are not used as extensively, is serviced by a station having the following equipment: one 10-in. aluminum-oxide bench grinder, one 10-in. silicon-cup wheel grinder, one 6-in. diamond wheel grinder, and one chip-breaker diamond wheel grinder.

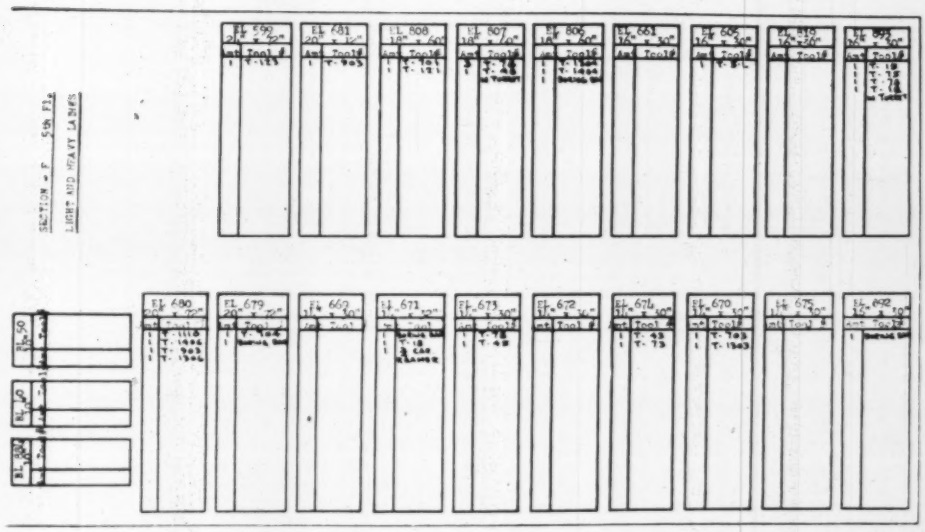

FIG. 5 CARBIDE FLOOR PLAN

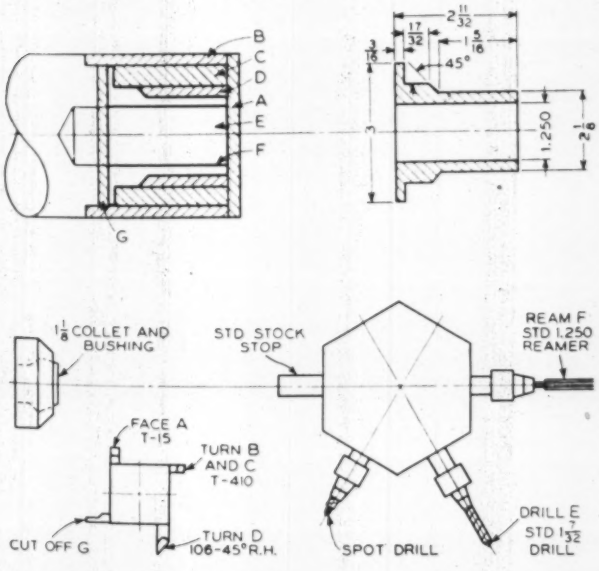

FIG. 4 SKETCH OF WORKPIECE AND TOOLS USED ON EACH OPERATION

Carbide Application Men. Thirty-five carbide-application instructors, mechanics who had taken the course of instruction previously mentioned, are assigned to touch-up stations. They are responsible for the application and control of all carbide tools used in their respective sections. Their work is similar to that of set-up men in a production shop, and their duties include designation of sequence of operation, the rpm, the sfm, feed, depth of cut and the correct style and grade of the carbide tools used. When possible, these data are compiled before the job is set up on the machine, with the aid of advance information secured from the planning office. These instructors also supervise the work of the grinding personnel in the touch-up station.

Carbide Application Cards. Pertinent information and data compiled by application men are recorded on the carbide application card, illustrated in Fig. 3. This card is posted at the machine and remains there until the job is completed. Although the application instructors set the machining standards on each operation, it is the duty of the regular floor supervisor to see that instructions on the card are followed. Upon completion of the job, the application card is returned to the touch-up station and filed by job plan number for future use.

For turret-lathe work, where several operations are performed in sequence on the same machine, additional information is compiled on the back of the application card, as illustrated in Fig. 4. On this side of the card is a process sketch of the workpiece, together with a sketch of the corresponding tool used on each operation. Each operation and each tool are numbered correspondingly to show the correct sequence. Advantages of this information are (1) to insure the use of the best machining methods, (2) to facilitate setting up the job, and (3) to permit the use of less skilled operators by decreasing the learning period on a new job. The indication of the sequence of operation and the process drawing serve as an incentive to application instructors and machine operators for suggested improvements, and these suggestions are adopted when saving in time and effort can be realized. The card also serves as an in-

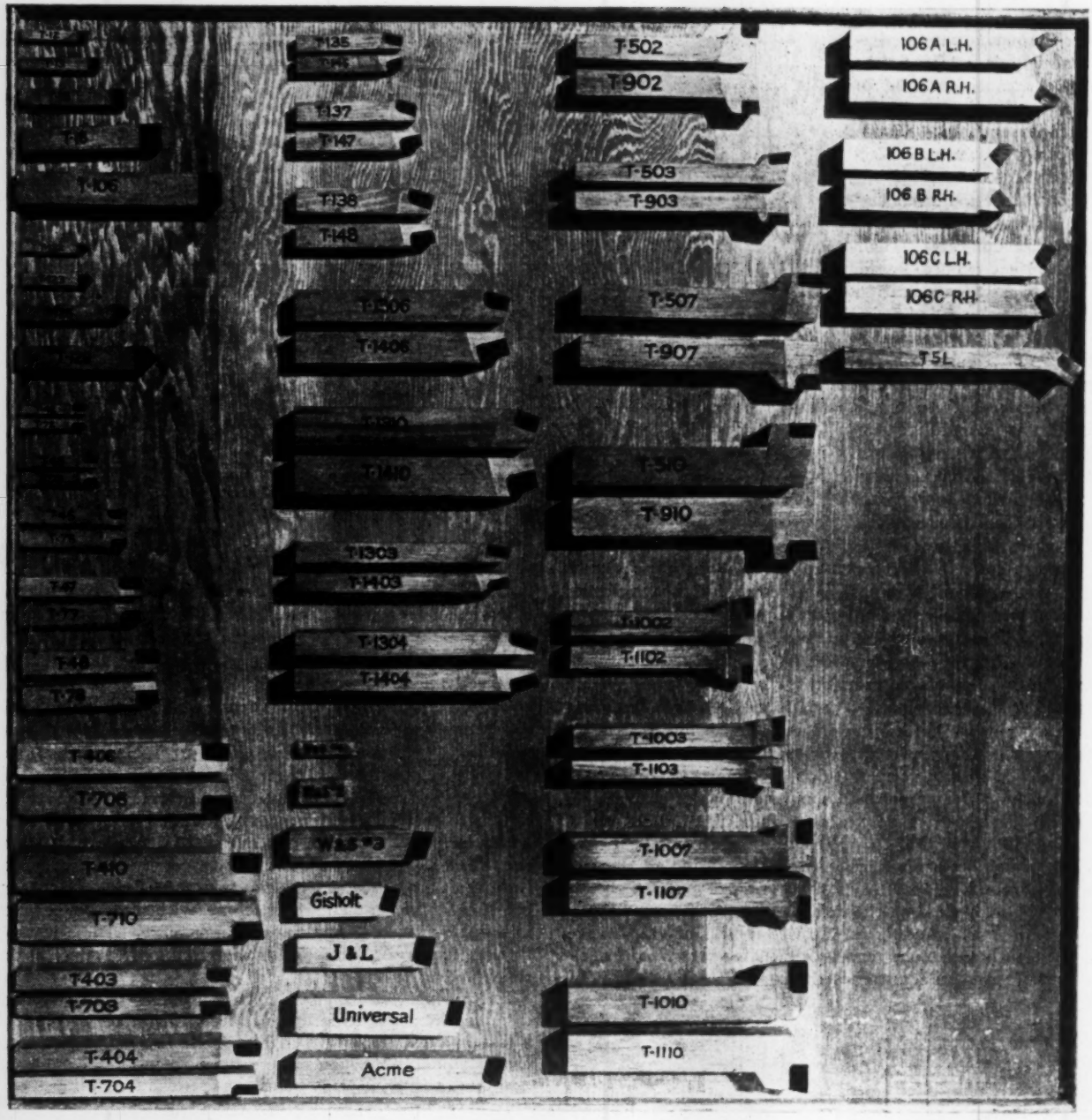

FIG. 6 STANDARD STYLES OF CARBIDE TOOLS

valuable record when the job is repeated. Since the card remains on the machine until the job is completed, necessity for turning in the tool at the end of each shift or making one man responsible for the tool is eliminated. Also, with the change of each shift, time is saved by permitting immediate operation without retooling the job.

Floor Plan. For control of the tools in each section, the application men use a form known as the carbide floor plan, illustrated in Fig. 5. This floor plan outlines a space for each machine tool in the section. As tools are drawn out of the touch-up station, the quantity, type, and grade are recorded in the space allotted to the machine using the tools. This information remains on the floor plan as long as the tools are used on the machine. When returned to the touch-up station, the data are crossed off the floor plan, showing that the tools have been returned. The floor plan makes it possible for the application instructor to locate and to make a periodic check on all carbide tools in his section, in order to determine when regrinding is necessary and to make certain the performance is satisfactory.

Carbide Training Program. Due to the tremendous difference between the operating speeds and cutting characteristics of carbide tools and those of high-speed tools, it was necessary to give the application men a thorough basic training course covering the manufacture, design, application, and grinding of carbide tools. In addition to the basic course, the application men attend biweekly meetings where they are informed of developments in carbide tooling and where they develop and work out systems and procedures for standardizing control and application of carbide tools throughout the shipyard.

Further, in order to obtain full support for the program, a brief course on general rules for the use of carbide tools was given to shop supervisors.

Standard Tooling. Due to the many and diversified types of machine operations encountered at the New York Naval Shipyard, it is necessary to specify a particular grade of carbide as a general-purpose steel-cutting grade and another grade as a general-purpose nonferrous-cutting carbide. These grades were so designated after testing representative carbide grades and selecting the grade most adaptable to shipyard work. The standard styles of tools, illustrated in Fig. 6, in use at the New York Naval Shipyard were developed to suit the needs of many types of machine operations.

On these standard tools, a secondary relief angle of 10 deg is ground with a 54-grit silicon wheel, and a primary relief angle of 7 deg is finish-ground with a 320-grit vitrified-diamond wheel. Quantities of these standard tools are stocked in the central carbide room and enough tools are drawn out by the touch-up stations for each 24-hr period.

Also, a standardized chip breaker is ground on these standard tools. This chip breaker consists of a parallel groove with a negative land along the cutting edge. The groove is 0.005 in. deep, and the width is varied to suit the depth of cut. The negative land is 0.020 in. wide and 2 deg negative for tools less than 1 in.; for tools over 1-in. the land is an average of 5 deg negative. The chip breaker is ground with a 180-grit diamond wheel, 3 in. diam and $^1/_{16}$ in. thick. The grinder head is moved off parallel 7 deg from the tool, thereby generating a curved path and supplying a means for governing the width of the groove.

This chip breaker (1) promotes a freer cutting action, due to the 11-deg positive rake in the curved groove; (2) has a stronger cutting edge, due to the negative land; and (3) can be ground much faster and with much less waste of carbide than the step type because of the 0.005-in. depth, compared to the 0.020-in. depth in the step type.

Special Tools. A large variety of special tools have been developed and used at this shipyard. Some representative types are listed as follows:

1 Groove tools, $^1/_4$ in. up to 1 in., to machine to a 2-in. depth.

2 Boring tools, ground with special angle for a particular diameter bore and shoulder contour.

3 Radius tools, concave and convex, ground with a special radius for a particular job.

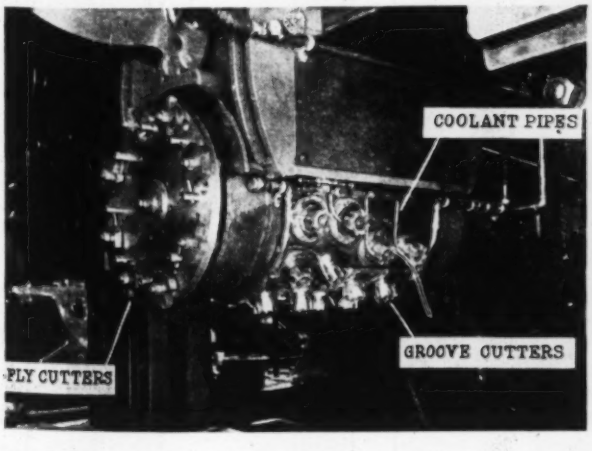

FIG. 7 MULTIPLE MILLING HEAD SHOWING CARBIDE-TIPPED GROOVE AND FLY CUTTERS

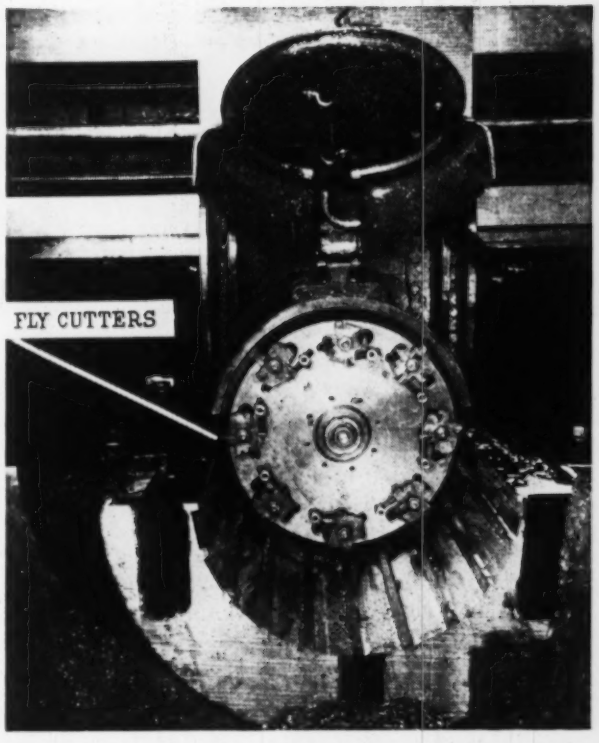

FIG. 8 MILLING HEAD IN CUTTING POSITION SHOWING GROOVE IN HALF-BEARING AND FACING PLATE WHICH IS EQUIPPED WITH CARBIDE-TIPPED FLY CUTTERS

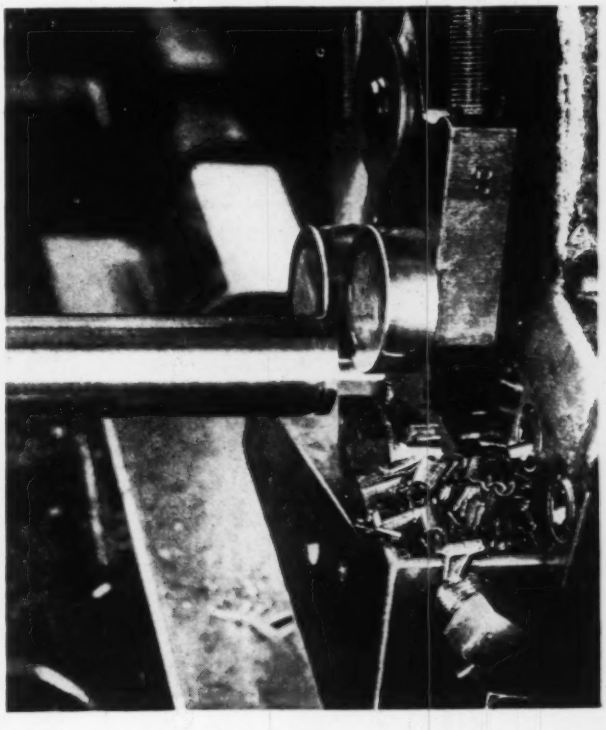

FIG. 9 CARBIDE-TIPPED ROLLER-TURNER TOOL SHOWING GROOVE-TYPE CHIP BREAKER

4 Multiple-form tools for valve bodies and valve seats.

5 Angular tools, specially ground to machine a certain angle.

Due to the small lots of work, it was necessary to compile repeat items before making up these special tools. When tools, such as those just listed, are made up for a particular job, they are stored in the touch-up stations in a box containing all the special tools for that particular job. A sample of the part together with a description of the tool is mounted on the outside of the box for identification. This system for control of special tools is used in conjunction with the application card for each special job.

EXAMPLES OF SPECIALIZED CARBIDE APPLICATIONS

Milling Shaft Bearings The demand for increased production of propeller-shaft bearings stimulated the development of a rapid machining method to supplant a slow and cumbersome technique that was being used.

Shaft bearings are made up of two semicircular bronze castings 12 to 14 ft long, with an inside diameter of 23 in. Ten dovetail grooves, filled with rubber or lignum-vitae strips which support the shaft, must be machined longitudinally in each half-bearing. By the former method, that of individually machining each groove on a planer, each half-shell took 60 hr to complete.

A multiple-head milling cutter, which reduced machining time for each half-bearing to 3 hr, was fitted to the crosshead of the planer, Fig. 7. This head holds 10 pairs of carbide-tipped milling cutters, one pair for each groove to be cut. The cutters are driven through a telescoping shaft by a motor mounted on the rear of the planer. This telescoping shaft allows full travel for the planer table. The table-travel speed was reduced so that this speed could be used as the feeding speed.

The half-bearing is placed on the planer table in a semicircular cradle and fed into the cutters, rotating at 400 rpm (320 sfm), at a rate of 0.001 in. per tooth. All ten grooves are rough-cut with one pass of the table. The leading cutter sizes the bottom of the groove and the following cutter dovetails the groove. The roughing cutters are replaced with finishing cutters for the second pass. When a number of bearings are to be machined, they are all rough-machined and later finish-machined.

At the same time, a facing plate, Fig. 8, which holds 8 carbide fly cutters, bores the bearing to the correct inside diameter. This facing plate, rotating at 110 rpm (690 sfm) with a feed rate of 0.008 in. per tool, is powered by the same motor.

Roller-Turner Carbide-Tipped Tools. The roller-turner tools, Fig. 9, used at the New York Naval Shipyard have given remarkable results. These tools showed an increase in production of 500 per cent over high-speed tools, because of the effective cutting angles used.

These tools are ground to the following angles: (1) 9 deg front relief, (2) 13 deg side relief, (3) 18 deg back rake, (4) 20 deg side rake, and (5) a lead angle of $3\frac{1}{2}$ deg. However, due to the chip groove used, an effective side-rake angle of 11 deg positive was obtained. This groove is 0.018 in. wide and has a 2-deg negative edge land.

The 11-deg positive side rake makes for a much freer-cutting tool, resulting in less top wear on the tool, and the 2-deg negative land prevents the edge from breaking down. These two factors enable the use of speeds of 300 sfm with feeds up to 0.020 in. The average tool life is 8 hr per grind.

Numerous other special jobs have been tooled with carbides with satisfactory to remarkable results. However, enough has been written to show that carbides are an important phase of the tooling program in the shipyard machine shops and have played a prominent role in helping to put the ships on the firing line.

Courtesy The Linde Air Products Company

THE AUTOMATIC UNIONMELT WELDING PROCESS

(A standard fabrication technique in many automobile parts production plants. Here a unionmelt machine—one of a battery of three—is welding the differential housing to the axle assembly used in a four-wheel-drive truck.)

CRUSH-DRESSING *of* GRINDING WHEELS

By RICHARD Y. MOSS

PRODUCTION ENGINEERING MANAGER, THE SHEFFIELD CORPORATION, DAYTON, OHIO

CRUSH-dressing during the last year has been more widely applied in both toolroom and large volume production than during its many previous years of industrial and experimental use. No drastically new variations of the technique have appeared. Further developments of the process have rather taken the direction of refinement of different details.

This paper is intended to outline a concensus of many users of the method as to best current practice, and to set forth certain test information which supports the prospect that wider industrial applications in many fields may logically be expected.

Crush-dressing of abrasive wheels, by common usage, is the process of truing the wheel face in a flat form or variable profile by annular rolling contact of a forming roll operating at reduced speed.

The wheel most widely used is aluminum oxide, with vitrified bond. Silicon-carbide grit can be crush-dressed effectively, but there are fewer applications for this abrasive. Finer grain size is generally used with crush-dressing than with diamond-truing. Grit as fine as 400 is used where small fillets must be maintained on precise contours. Structures and grades of wheels are around medium, varying toward open or dense, soft or hard for particular applications. No essentially successful application of crush-dressing to organic-bond wheels has been reported. The minimum fillet obtainable may be closely related to grit size used in a crush-dressed wheel.

A wide variety of forms are being crush-dressed in industrial practice today, ranging from flat faces through simple radii to complex combinations of angles, radii, and generated forms. Crushers for 4-in. wheel faces are common.

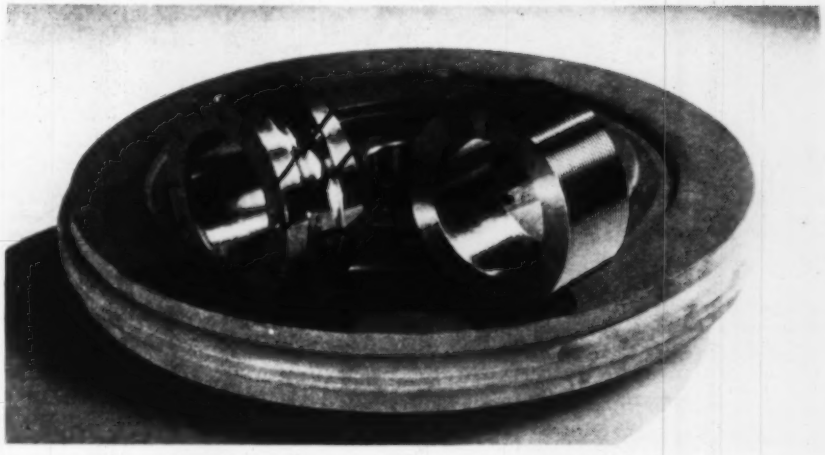

FIG. 1 TWELVE-INCH GRINDING WHEEL TO CRUSHED-DRESSED COMPOUND RADII OF FORM ON CRUSHER ROLL AT LEFT

(Crushers for irregular forms of this sort are generally gashed; 20-pitch U. S. form-thread crusher roll at right is normally left without gashes.)

CRUSHER ROLLS AND THEIR OPERATION

Crusher rolls are made from soft steel, hard steel, extremely hard alloy steels, and various cemented carbides. Greatest economy for long runs is indicated right now in the use of fine-grained high-speed steels and abrasion-resistant die steels of the basic high-carbon high-chromium types. Crusher rolls of materials with extremely hard grains in comparatively soft matrices appear to show less effective life in relation to cost than those of materials which are less hard but more nearly homogeneous.

Rolls are made with and without irregularly spaced angular gashes, Fig. 1. Crusher rolls for United States Form 60-deg threads have been tested with and without gashes, showing almost identical wear life. It may be assumed that the beneficial effect of the gashes in providing channels for loose grit removal and periodic wheel penetration is about equal to the added roll life provided by greater surface area on roll periphery.

Reduced speed of the abrasive wheel and roll for dressing is variously obtained through frictional contact. The wheel may drive the roll, or the roll may drive the wheel. Power or manual turning may be used in either case. Feed of roll into wheel may be achieved by hand or power, and may be intermittent or continuous. Dressing surface speeds range up to 350 surface ft per min with satisfactory results. Certainly the object is absolutely minimum continuous or intermittent slippage between roll and wheel. Continuous slippage is largely caused by resistance to rotation of whichever member is driven, or by diameter differentials in the form on the roll. Intermittent slippage may be equally harmful to roll life where deep forms are dressed. It appears to be caused by minute acceleration and deceleration of either the driving or driven member. Using the member of greatest mass and inertia, generally the wheel, as driver appears to minimize this latter effect. Existence of this condition may be observed in a used crusher roll as a dark irregular line between lighter frosted or satin-finish areas. This line is apparently the radius of true rolling contact of roll with wheel. If this line has a regular radius with respect to crusher center line, it may be considered that the condition of variable slippage, harmful to roll life, does not exist.

Coolant serves a dual purpose in crush-grinding applications. It assists the dressing operation, as well as the grinding operation after dressing.

Contributed by the Research Committee on Metal Cutting Data and Bibliography and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

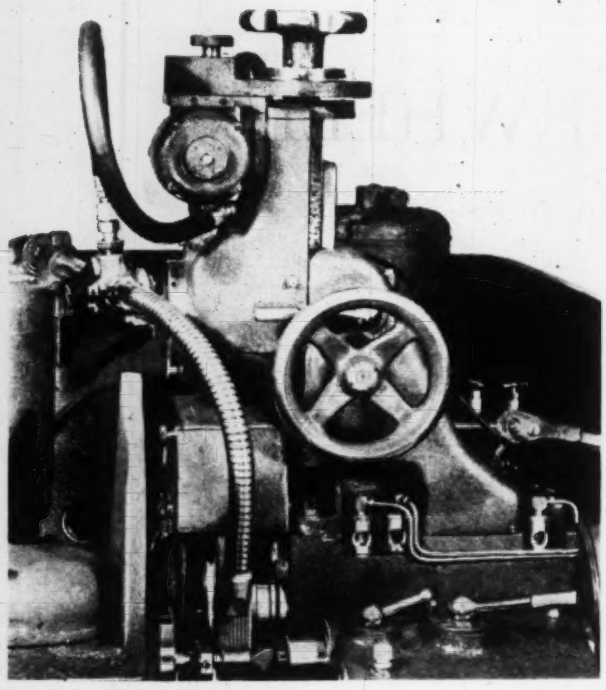

FIG. 2 CLOSE-UP OF THREAD AND FORM GRINDING MACHINE USING 1-IN. WHEEL FACE, CRUSH-DRESSED TO 20-PITCH U. S. FORM FOR PLUNGE-GRINDING $^3/_4$-20 THREAD IN $1^1/_2$ THREAD REVOLUTIONS OF WORKPIECE

(For dressing operation, wheel guard is removed and crusher housing, top center, lowered to bring crusher roll into contact with work.)

In dressing, the coolant lubricates the contact area between wheel and roll, and washes away detached grit. A medium-viscosity thread-grinding oil with some extreme-pressure characteristics gives a satisfactory result. The high film strength of an extreme-pressure type of oil appears to minimize crusher penetration and abrasion by the grits of the abrasive wheel. The oil must be reasonably fluid to pick up and carry away detached grains. It is here that gashes in a crusher roll probably are of greatest utility.

Compressed air is also effective as a dressing aid, when used with dry wheels, because of its ability to blow away loose grit. This method can be used satisfactorily in cases where an extremely good exhaust system is available.

Soluble or emulsified coolants have not been conspicuously successful in crush-grinding applications. More crushing pressure is required. Tests have often resulted in fracture of portions of the grinding wheel. This is believed to be due to absence of lubricant film strength, which localizes crushing pressure on the wheel in the plane of roll and wheel axes. Soluble coolants should be quite as effective as oil in carrying away detached grit.

Comparative coolant effectiveness in the grinding operations after crush-dressing is in line with commercial practice. Profiled wheel form produced by any method is maintained longer with oil as the coolant. Practical limitations ordinarily preclude using oilf or crushing and soluble coolant for grinding.

This review of current practice has outlined fundamentals which are generally used in applications of crush-forming. Certainly many of the choices which have been indicated as "preferred" will be specifically improved with further research and production experience.

ADVANTAGES OF CRUSH-DRESSING

In an earlier paper, W. F. Aller[1] listed six points of advantage which might be claimed for crush dressing, which were as follows:

1 Reduced time for dressing operation.
2 Better and sharper cutting surface on wheel.
3 Number of pieces ground per dressing is increased.
4 Dressing-tool cost is reduced in many cases.
5 Longer total wheel life.
6 Reduced burning and pressure on work.

Some comment may be made on these points, which have in the main been well supported through another year's experience. Dressing-roll cost, if segregated and compared with diamond cost for those forms where a diamond can be used on a complex profile, will often exceed net diamond cost.

The cost of dressing, if determined to include tool cost, dressing time and dresser set-up time, and then prorated over pieces ground per dressing, will infrequently show crushing to be more expensive than diamond-dressing for comparable wheel profiles.

Ultimate accuracy of wheel profile will favor diamond dressing over crush-dressing for tolerances which approach gage accuracy with very light cuts. This is largely a result of minute deflections in a grinding machine as a result of pressures required for crushing. These deflections can occur throughout the machine and its various lubricating-oil films. The single point diamond used in profile-dressing exerts little pressure and causes less total deflection. Offsetting this, a wide-face diamond-dressed wheel will exert considerably more grinding pressure, require longer grinding time, and parts must be preformed for grinding. Here again, the major factor in comparison is the ability to diamond-dress complex wheel forms. Even if the profile can be diamond-dressed, the greater cutting ability of a crush-dressed wheel, removing much more stock per dressing, with less pressure on the work, warrants careful consideration. Certainly a major factor in obtaining maximum possible accuracy in any wide-face contour grinding is as much the reduction of work deflection as it is precision of wheel form.

COMPARATIVE CUTTING TESTS

A series of tests have been conducted to establish some more definite knowledge of comparative cutting abilities of crush-dressed and diamond-dressed faces on a grinding wheel.

The primary determination in these tests has been the measurement of net power consumed in a series of prescribed cuts, duplicating all conditions except dressing method to obtain the comparisons.

In the first test, work diameters, work speeds, and wheel-face width were varied to obtain a constant rate of metal removal in different materials, plunge-grinding a 20-pitch U. S. form thread in one full turn of the work at depth.

In the second test, the same procedure was followed, removing a constant volume of metal per minute, with a straight flat wheel face, either diamond- or crush-dressed.

In the third test a crushed 20-pitch thread form on the 1-in wheel face was used at several increased work speeds to show the effect of faster stock removal on wheel dulling and total power consumption.

The machine used for the test was a Sheffield thread and form grinder, which was readily adaptable to all requirements.

No attempt was made to compare a "best" wheel for crushing and a "best" wheel for diamond-dressing. This study concerned relative cutting abilities of surfaces on a general-purpose

[1] "Dressing Grinding Wheels," by W. F. Aller, MECHANICAL ENGINEERING, vol. 66, 1944, pp. 779–782; discussion and author's closure, MECHANICAL ENGINEERING, vol. 67, 1945, pp. 681–682.

wheel after preparation by both truing methods. The wheel chosen was an aluminum-oxide, 220-grit vitrified-bond wheel which has been successfully used for a number of years with both dressing methods. One wheel, with 1-in. face, was used throughout the test, cutting down width when a narrower face was required. Wheel speed was held in the range of 5700 to 6000 sfpm throughout the experiment.

A standard thread-grinding oil coolant, filtered but not refrigerated, was used. No appreciable temperature rise was recorded at any time during the test. The 20-pitch thread form was crushed on the 1-in. wheel face with a standard, ungashed crusher roll; it was diamond-dressed on the same wheel with a cam-actuated diamond dresser mounted between work centers, using a lapped 50-deg chisel-point diamond. A diamond feed of about 0.0002 in. per revolution of the wheel was used on both thread- and flat-form dressing. About 0.004 in. was removed from the wheel radius in diamond-redressing, and about 0.0025 in. from the wheel radius in crush-redressing.

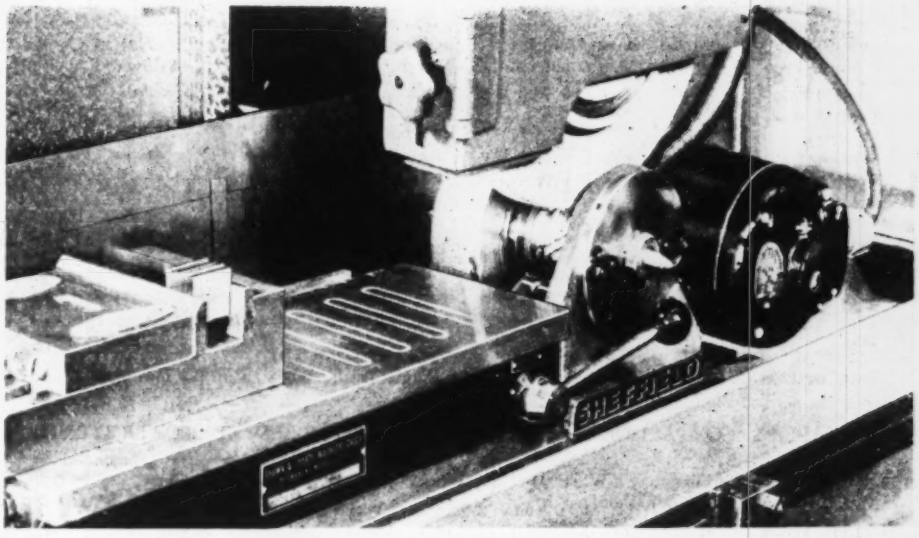

FIG. 3 TYPICAL SURFACE GRINDER SET UP WITH MOTOR-DRIVEN CRUSHER DEVICE MOUNTED ON TABLE ADJACENT TO MAGNETIC CHUCK

(This type can be applied to any standard surface grinder for grinding irregular contours and flat work.)

Power consumption was recorded on the chart of a standard recording wattmeter connected to the wheel-drive motor circuit only. Using a tape feed of 2 in. per min, instantaneous power requirements were recorded on each cut.

The wattmeter tests were interpreted to show net energy required for the cut. It was felt that excess energy required over that used to remove metal at the desired rate initially could only be expended as heat at the point of contact of wheel with work, resulting in possible heat damage to the product. Observation of the tests and inspection of the work samples confirmed this.

RESULTS OF TESTS

In observing the tabulated test results it will be helpful to have in mind the type of wattmeter chart produced by successive identical cuts after redressing the wheel. In each test the wheel was briskly plunged to full cut depth. The rate of dulling of the wheel thereafter was indicated by a slope which showed a constantly climbing power load. On soft materials both dressing methods showed a comparatively slow rate of dulling. On hard material this rate was accelerated, with the diamond-dressed form frequently failing to cut, and burning severely at the predetermined volume rate of metal removal. On high-speed steel at 63-65 Rockwell C scale, the highest rate of dulling was observed with a crush-dressed wheel, while the diamond-dressed wheel failed to take the plunge cut.

Table 1 shows comparative cutting abilities in plunge-grinding of the diamond-dressed and the crush-dressed wheels under identical conditions working at a constant rate of stock removal in various materials. The first five columns are self-explanatory; some definition is required for the "net power" columns. "Net kilowatts" is actual power increase for the cut, over no-load input, corrected for drive-motor efficiency, measured as the mean for the first piece after wheel-dressing in each case.

It was previously mentioned and shown that a regular rate of wheel dulling was observed. This has been translated to a figure of instantaneous kilowatt-net-load increase per minute of cut, or, as in Table 1, increase per 0.048 cu in. metal removal.

For plunge-grinding with freedom from excess heating then, we can predetermine length of cut up to a point where coolant heat transfer is insufficient to avoid this common grinding trouble.

The diamond-dressed wheel was partially backed out of the cut in those cases where "Burn—2 turns" is noted, literally because of the hazard of an oil fire. Work was severely damaged. The irregularities of diamond-dressing, even when performed mechanically as in this case, are evident in the various "load" and "climb" figures shown.

No evidence of heat damage was observed in any of the crush-ground specimens. The high rate of climb on 1-in-diam high-speed steel would, however, at this rate of stock removal, make dressing for each piece necessary in plunge-grinding.

No exact explanation is offered for the variations of load and climb on different diameters and widths of work; this may be a combination of grit "tooth load" due to work-speed variations, and arc of contact differences. The greatest tooth load and arc of contact occurred on the hard 4-in-diam specimen under "Crush," and showed greatest comparative efficiency at the prescribed metal-removal rate. The diamond-dressed wheel failed completely on both hard and soft specimens at this point. This would support the theory that a crush-dressed wheel derives its greatest advantage from more cutting grits and greater clearance between grits.

Table 2 is similar to Table 1, except that the wheel was dressed flat and plunged to a depth to permit the same rate of metal removal per minute as in Table 1.

In this test, mechanical diamond-feed rates for dressing were the same as in the thread-form dressing, around 0.0002 in. per wheel revolution. The improvement in wheel cutting ability may possibly be attributable to a diamond-axis position more nearly normal to wheel surface.

Doubling crushing depth on the fourth item had a marked effect on wheel cutting ability in that test. An entirely fresh wheel surface was exposed.

A general comparison of crushing net power and climb in Table 2 with the same metal removal in Table 1 reflects reason-

TABLE 1 COMPARISON OF CRUSH- AND DIAMOND-DRESS NET POWER CONSUMPTION TO PLUNGE-GRIND[a]

Metal	Metal hardness	Work diameter, in.	Work length, in.	Work rpm	Diamond: Net kilowatts	Diamond: Kilowatts climb per min	Crush: Net kilowatts	Crush: Kilowatts climb per min
Aluminum	Soft	0.980	1.000	1.01	1.04	0.05	0.87	0.01
Brass	Soft	0.980	1.000	1.01	1.90	0.08	0.81	0.01
4615	Soft	0.250	1.000	3.95	1.85	0.54	0.78	0.05
4615	Soft	0.480	1.000	2.02	2.40	0.74	0.61	0.05
4615	Soft	0.980	1.000	1.01	2.70	0.61	1.01	0.04
4615	Soft	2.000	0.500	1.01	1.82	0.20	0.74	0.03
4615	Soft	4.000	0.250	1.01	1.80	Burn 2 turns	0.74	0.03
4615	60[b]	0.250	1.000	3.95	1.90 +	Burn 2 turns	0.84	0.10
4615	60[b]	0.480	1.000	2.02	2.00 +	Burn 2 turns	0.76	0.10
4615	60[b]	0.980	1.000	1.01	1.60 +	Burn 2 turns	1.14	0.22
4615	60[b]	2.000	0.500	1.01	2.00 +	Burn 2 + turns	0.84	0.10
4615	60[b]	4.000	0.250	1.01	1.80 +	Burn 2 turns	0.84	0.07
HSS	64[b]	0.980	1.000	1.01	Burn	No plunge	1.90	1.60

[a] Tests were on U. S. form thread, 20 pitch; 0.0325 single depth; 0.048 cu in. per min metal removed. [b] Rockwell C hardness.

TABLE 2 COMPARISON OF CRUSH- AND DIAMOND-DRESS NET POWER CONSUMPTION TO PLUNGE-GRIND[a]

Metal	Metal hardness	Work diameter, in.	Work length	Work rpm	Diamond: Net kilowatts	Diamond: Kilowatts climb per min.	Crush: Net kilowatts	Crush: Kilowatts climb per min.
4615	60[b]	0.250	1.000	3.95	0.97	0.40	0.78	0.23
4615	60[b]	0.480	1.000	2.02	1.01	0.35	0.87	0.25
4615	Soft	0.980	1.000	1.01	1.38	0.23	1.14	0.08
4615	20[b]	0.980	1.000	1.01	1.55	0.17	0.67[c]	0.04
4615	60[b]	0.980	1.000	1.01	2.30	1.35 first cut bad burn	1.45	0.18
4615	60[b]	2.000	0.500	1.01	1.10	0.67	0.67	0.10
4615	60[b]	4.000	0.250	1.01	0.88	0.67	0.60	0.06

[a] Flat wheel face; 0.0163 single depth; 0.048 cu in. per min. metal removal. [b] Rockwell C hardness. [c] Crushed 0.004 instead of 0.002 in.

able consistency of crushed-wheel performance, even though face area of the wheel is about one half that of thread-form tests in Table 1. The difference in diamond-dressed cutting ability, between Tables 1 and 2, illustrates the wide range of results on a single wheel which may be obtained through use of diamonds, even when mechanically fed.

Table 3 is confined to crushing only, with a 20-pitch thread form on the wheel, at accelerated rates of metal removal. Item 1, Table 3, duplicates a similar entry on Table 1, showing a slight variation of climb rate.

Item 2 is identical to item 1, except that rate of metal removal has been increased 212 per cent. Note that initial power consumption increased only 30 per cent, while rate of climb increased only 53 per cent.

Item 3 lists a different part size, with metal-removal rate twice that of item 1, but lower load and climb rate. Here work speed, arc of contact, and material hardness are probably factors.

Item 4 is identical to item 3, except that rate of metal removal has been increased 50 per cent. In this case, initial load increased 42 per cent, but rate of climb decreased slightly.

The figures in Table 3, rather than permitting a conclusion, illustrate that a wide range of results in high-production plunge-grinding may be obtained through variation of work speeds with crush-grinding. Undoubtedly wheel breakdown is greater in the cases where higher volumes of metal are removed, although this effect was not measurable on small sample runs. All items were held well within Class 3 thread-form requirements in this test.

TABLE 3 EFFECT OF STOCK-REMOVAL RATE ON WHEEL DULLING WITH CRUSH-DRESSED WHEELS[a]

Metal	Metal hardness	Work diameter, in.	Work length, in.	Work rpm	Metal removed, cu in. per min	Net power: Kilowatts	Net power: Kilowatt climb per min
4615	60[b]	0.980	1.000	1.01	0.048	1.14	0.28
4615	60[b]	0.980	1.000	3.16	0.150	1.48	0.43
4615	50[b]	0.750	0.875	3.16	0.101	0.97	0.21
4615	50[b]	0.750	0.875	4.90	0.151	1.38	0.19

[a] Plunge-grinding, 20-pitch U. S. form thread; 0.325 single depths.
[b] Rockwell C hardness.

CONCLUSION

Thread and other profile grinding is most successful where wheel breakdown is minimized. In flat or cylindrical grinding operations, using wheel periphery or face, progressive wheel breakdown is desirable and essential, producing much the same wheel surface as obtained by crushing.

In conclusion, it may be considered that a comparison of grinding ability between diamond-dressing and crush-dressing is derived only under fixed conditions and is then the comparison of two essentially straight-line slopes, with diamond-dressing showing a much steeper slope, with higher initial load value.

If we extend this analysis, and consider that the accumulated load increase at any instant is probably largely expended as excess heat at the arc of wheel contact, then the coolant and burning problems can be directly anticipated. Excess load of 1 kw over the net cutting-power requirement can produce heat energy equal to 0.95 Btu per sec. The observations cited previously would indicate that this amount of excess load can easily be achieved in flat or profile grinding. Since the rate of heat transfer into the work is fairly slow, this resolves the coolant problem, and establishes that wheel-dressing must be sufficiently frequent to keep this heat generation within the requirements of the job. It offers proof that in any commercial application, where form is appropriate, the vastly greater freedom of cutting of a crush-dressed wheel permits many more pieces per dressing, a much shorter work cycle, and removal of much more grinding stock, with equivalent result in the product and greater economy in the operation.

Knowledge of these relationships, and further extension of the knowledge, should lead to careful re-examination of many industrial machining operations which have heretofore not been economically feasible for grinding methods. Certainly, the possibilities of greater economies in grinding operations are made obvious.

RUSTING CHARACTERISTICS *of* TURBINE LUBRICATING OILS

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USUALLY, when we discuss the characteristics of turbine oils, we consider oxidation, emulsion, life, etc., all desirable and positive in nature, but in this paper we will concern ourselves with a negative characteristic, that of rusting, for one usually associates oil with the prevention of rusting.

The tremendous difference in design between large and small turbines and between the old and newer-type units is well known. The complex design of the modern turbine oiling system renders dismantling for cleaning difficult and expensive. The higher pressures, with their attendant higher temperatures, and the extremely intricate and closely fitted parts in the control apparatus of the modern turbine could not tolerate the use of the older-type normally refined oils. Thus with the advance in turbine design there has been an advance in the development of the lubricating oils.

If it were possible to stop and clean a turbine at short intervals, the turbine oil of former years might still be used successfully. However, with a modern turbine called upon to operate continuously for a year or longer without stopping for cleaning or adjustment, the use of an oil with desirable long-life features becomes of extreme importance.

In the case of turbine oil of 15 or 20 years ago, it was almost universally agreed that, when the neutralization number reached 0.50, the oil should be removed. During its life, it had usually been "sweetened" by the addition of new oil from time to time. We know that these older oils deteriorated readily in comparison with the life of the modern oil, that the products of deterioration resulted in heavy sludges and deposition of "varnishes" on the metal surfaces, and that the thickness of these deposits increased until they would eventually interfere with the normal lubrication of the turbine, in that clearances were markedly reduced, particularly where close clearances exist as in the case of the governing apparatus.

Certainly, no turbine-oil user would want to go back to the older types of oil; in fact, it is questionable if we would care to use them in the modern turbine. We cannot recall that the turbine manufacturers told the refiners that they must "build" a better oil, or that the turbine builder and the refiner met and decided to build better turbines and oils. On the other hand, improved turbines and turbine oils were the result of modern research and development. As a representative of a turbine manufacturer, the author cannot but state that the refiners most certainly have done their part in developing and supplying suitable, stable, long-life lubricants for the modern turbines.

DEVELOPMENT OF MODERN TURBINE OILS

The development of the modern stable turbine oil was not immediate but resulted from continued research during a transition period of some 15 to 20 years, combined with the advent of solvent and other improved methods of refining.

In general, each improvement in refining (improvements in removing undesirable components) resulted in definitely improved oil in terms of prolonged operating life, resistance to sludging and normal breakdown, with the elimination of the deposition of "varnishes" previously mentioned.

In this discussion of rusting characteristics, we must pause to touch on the matter of moisture in turbine lubricating systems. To exclude moisture entirely from turbine lubricating systems is practically impossible. The presence of moisture aggravates emulsification, sludging, and corrosion from built-up acid content in the oil. With the modern turbine oil, these conditions have been eliminated to a very great extent, but in their place we encounter corrosion and rusting when water is present.

The nonrusting characteristics of oils are dependent upon their ability preferentially to "wet" the surface of the metal in the presence of water. In the older types of oil this wetting ability was in general inherent in the oil; however, it appears that the components in the oil which provided for this wetting ability were also those which contributed to the earlier deterioration mentioned. Thus through their removal oil life was improved, but the wetting ability was decreased, and as a result rusting was encountered.

Corrosion resulting from the formation of high acid content in an oil and the subsequent attack of metallic surfaces and the formation of metallic soaps has been practically eliminated. The corrosion or rusting when water is present in the modern oil is of a different nature and began to be encountered some 10 years ago with the advent of the increase in the use of highly refined oils. Corrosion was so severe in many cases that expensive shutdowns were necessary in order to recondition.

Fig. 1 shows three steel corrosion test pieces run early in 1937 and illustrates the type of corrosion encountered. While the test was not a rusting test in the strict sense, rusting was obtained as a "by-product" and pointed the way to future investigations.

It is this type of corrosion that occurred with the modern oils, and we would like to outline the developments leading to the "discovery" that modern highly refined oils allowed rust to form when moisture was present in the oil, particularly in a new system.

EARLY HISTORY OF RUSTING PROBLEM

For several years prior to April, 1937, we had been receiving reports from the field of lubrication difficulties from rusting, and it appeared that they could all be attributed to solvent-refined oils. Unfortunately, we were not afforded the opportunity to examine the oils in question or the residues. For some years up to that time, the number of instances brought to our attention, wherein turbine oil had sludged, oxidized, or broken down and caused bearing and other lubrication difficulties (other than rusting), had been reduced to a minimum. Rusting had occurred in both old and new units. In the older units, mechanical construction was such that rusting, while most undesirable, did not interfere materially with control; however, in the newer-type control systems, it materially affected operation.

Contributed by the Power and Fuels Divisions and presented at the Spring Meeting, Chattanooga, Tenn., April 1–3, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

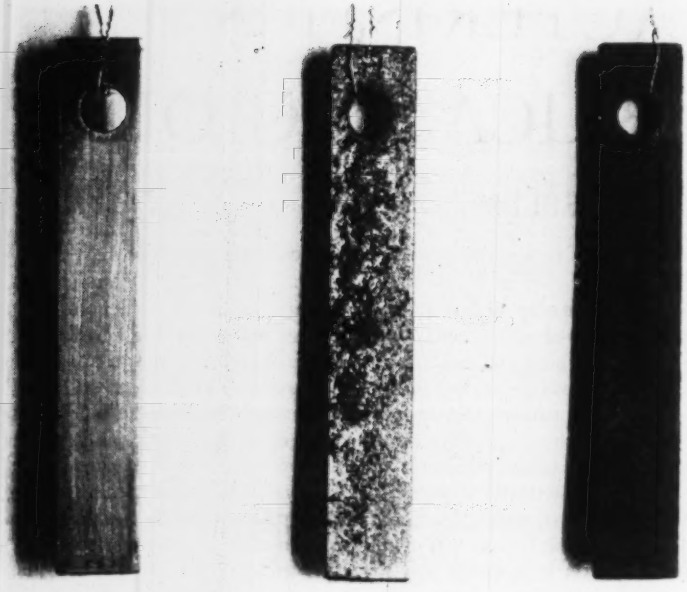

FIG. 1 STEEL CORROSION TEST PIECES

(Left to right: No. 6561 light turbine test oil, plain, 384 hr; No. 6561 light turbine test oil, 1 per cent water added, 384 hr; oil from De Laval gear case, 264 hr.)

Rusting had been the subject of a number of discussions with representatives of refiners, but our problems appeared to have been lightly dismissed.

Rusting, when using the more modern oils, was encountered on our tests floors. Admittedly we did not immediately recognize its source but tended to place the blame on improper shop practices, for how could an oil allow rust to form? Samples of residues found in the oiling system were identified principally as the black magnetic oxide of iron ordinarily known as mill scale. Thus, we took our shopmen to task for not cleaning parts before assembly, for this oxide forms only at temperatures of 600 F or above, and we reasoned it must have been in the piping or other parts. Later it was definitely established by our laboratory and other investigators that the product of oil-water corrosion on steel was the black oxide.

Then, in September, 1936, we were asked to investigate a report that some sort of an alkaline solution was being circulated in turbines in the field before oil was placed therein, to "kill the acid" in the steel, thus preventing future rusting of the parts. There is, of course, no acid in steel and we believe someone heard of acid open-hearth steel, a term derived from the type of furnace lining, and became confused in his reasoning. We were unable to secure confirmation on this supposed practice.

TRACKING DOWN THE SOURCE OF TROUBLE

The problem in the field increased in seriousness, and in 1937, in view of the fact that we did not appear to be making much headway in securing actual facts as to what rusting difficulties were being experienced by others, the author's company embarked on a program of incorporating oiling systems which were designed to lessen chances of contamination, water leaks, etc. It was believed that we would thus be in a better position to face the problem and make sure that everything we did in our shops would offset any sources of rusting. Meanwhile, laboratory investigations were under way. Then in April, 1938, corrosion was encountered in a 1200-lb 925 F topping turbine, using a modern highly refined oil. Rusting occurred within a period of a few hours and to such an extent that it became necessary to shut down and clean or replace certain steel governor parts; in fact, even some rust resisting steel parts showed signs of attack.

Samples of the oil were examined. Very little change from the original characteristics were noted other than a cloudiness due to moisture (we found 0.02 per cent moisture).

The samples were divided into two parts, the second being freed from moisture and contamination by heating and centrifuging. Polished steel specimens were then immersed in the original and cleaned samples. In the original the steel rusted severely within 24 hr, while that immersed in the cleaned oil showed absolutely no indications of rust or corrosion. The corrosion products on the rusted specimen were identified as black oxide of iron. Now it appeared we were approaching an answer to the trouble, as the cause of the rusting was obvious.

DEVELOPING A RUSTING TEST FOR OILS

Meanwhile, we had been investigating some of the solvent-refined oils, using a rusting test which we had devised. This test, an outline of which follows, is the forerunner of the present A.S.T.M. Test D 665-44T, the basic principles still being used. A 350-ml sample of oil was placed in a tall-form beaker and set up on a stirring device accommodating six samples. Stirring was started and a flat polished steel specimen was then suspended in the oil. After 10 min stirring, 1 per cent of distilled water was added and stirring continued daily for 8 hr at room temperature with an overnight shutdown period, for a total time of 5 days. Specimens were then removed and observed.

Evidence indicated that solvent-refined and highly refined oils appeared to be those allowing rust to form when water was present. It was as if something had been removed from these oils, perhaps natural wetting or inhibiting constituents. If so, we reasoned, from what had been stated by some refiners using solvent refining, these constituents would probably still be present in conventionally refined oils of the Pennsylvania, Mid-Continent, and Coastal types and naturally then, such oils would not allow rusting.

This reasoning was disproved early in our investigations covering tests numbering over 100 on various oils and combinations thereof, and including practically all of the turbine oils then on the market. Thus, early in 1939, we reached the conclusion that many highly refined oils, irrespective of their base or method of refining, were conducive to rusting and corrosion in the presence of water. With this evidence we started to contact the refiners and present our "story."

RESULTS OF TESTS

As an example of results obtained, a few typical results are given in Table 1.

It does not take much change in an oil to either "make or break" it, in so far as its rusting characteristics are concerned. As an example, the maker of oil No. 4 refines in two plants from the same crude and to the same finishing specifications. They desired to see what the oil from "their other refinery would do." It did not rust, yet it was essentially the same oil. Additional checks confirmed the results.

Again oil No. 7, which showed no rust, made from a single crude in a single refinery on an additional sample purchased some time later showed very bad rusting tendencies.

In the case of oil No. 5, to illustrate the effect of the degree of refinement on rusting, the supplier of this oil furnished samples of their "run" in two lower stages of refinement. That in the

TABLE 1 RESULTS OF RUSTING TESTS WITH VARIOUS OILS

Oil no.	A.P.I. gravity	Refining method	Remarks
1	32.0	Highly refined	Rusted badly
2	33.0	Lightly solvent	Rusted
3	28.4	Conventional	Rusted badly
4	32.0	Conventional	Rusted badly[a]
5	22.5	Conventional	Rusted badly
6	30.0	Solvent	Rusted badly
7	21.5	Conventional	No rust[b]
8	27.0	Vacuum still	Rusted badly[c]

[a] Stated to be a 100 per cent Pennsylvania oil.
[b] A coastal oil.
[c] A Mid-Continent oil.

lowest stage allowed no rust and the one midway between the lower and finished stock showed slight rusting.

A comparison (Table 2) of the inspection characteristics of several oils which allowed and did not allow rust may be of interest. In general, color, neutralization, and demulsibility indicative of the degree of refinement in a given type oil.

TABLE 2 COMPARISON OF INSPECTION CHARACTERISTICS OF VARIOUS OILS

	Rusting oils		Nonrusting	
A.P.I. gravity	28.4	22.5	28.6	21.5
Color	1	1½	4½	2½
Viscosity	150	155	220	157
Viscosity index	62	0	90	0
Neutralization number	0.02	0.01	0.08	0.10
S.E. number	30	45	60	100
Demulsibility	1620	1620	1300	1300 at 180
Carbon residue	0.03	0.02	0.19	0.02

During our investigations, it was determined that even the newer-type stable oils build up immunity to rusting as they age through use. However, sometimes they required as much as 12,000 to 15,000 service-hr before they would pass a rusting test.

Also, in our investigation we determined that rusting could be eliminated through the addition of used oil or by the addition of a nonrusting oil, by the addition of small amounts of fatty acids. Even the addition of a mineral cutting oil or some soluble oil (such as those mixed with water for cutting purposes) would eliminate rusting. Commercial polar compounds imparted inhibitive properties. However, in all these cases of additions, the other desirable characteristics of the oils were reduced to a considerable extent.

The author's company believed they had succeeded in showing what conditions existed and continued to press the refiners for a solution to the problem. We are not refiners but had presented the foundation for their subsequent investigations.

RUSTING "SHOWS UP" IN NAVY TESTS

We would like to point out one further incident in this rusting problem, one having to do with marine apparatus, showing that rusting was not confined to lighter oils, and which we believe was most instrumental in securing the Navy's interest in the problem. The company had always used a 425-sec second-grade turbine test oil for shop testing on marine reduction gears. Early in 1938, in testing marine apparatus, we were obliged to use Navy approved (Navy symbol 2190) oil. This oil has a viscosity of 185–205 sec at 130 F. On a special so-called "full-power" test, severe rusting was encountered during preliminary runs. The oil used was that currently being used by the Navy. A competitive approved oil was tried with no improvement and finally a second competitive oil, again with no improvement; in fact the last used oil rusted so badly that it is believed an outline of the conditions encountered will be of interest.

The last oil was chosen because of the fact that the refiner, whose aid had been solicited, had stated their "oil has not rusted on other gear installations" and who, in addition, offered the services of their marine engineer to aid in solving our difficulties. This engineer with the author concluded the test, the schedule for which follows:

Sept. 12. New oil in system.

Oct. 4. A black gritty deposit noted on back faces of gears. Not mill scale, as all parts had been pickled. Perhaps the rust was due to acid in the oil. Oil washed with neutral distilled water; however, no chlorides or sulphates detected and a pH of 6.8 found.

Oct. 5. Sample of oil removed from system. Water content 0.50 but no acidity; pH 6.85. Finely divided black iron oxide present in the sample. Was this contamination due to an improperly cleaned system? Oil removed, centrifuged, and replaced. Water removed by centrifuge showed pH of 6.75.

Oct. 7 to 10. Unit running and an apparent over-all improvement.

Oct. 12. Rusting again increasing. By-pass centrifuging.

Oct. 18. Conditions so bad unit had to be dismantled. Black-iron-oxide deposits over everything. Thrust-bearing shoe blocks severely attacked. Deposit identical to that found in the oil October 5, and in every way similar to deposits resulting from laboratory tests.

"PROVING" THE PROBLEM TO THE REFINER

The refiner's representative, who witnessed all operations, agreed that the conditions existing very definitely indicated that rusting had immediately proceeded during the period from September 12 to October 4. It was then decided to clean up the entire system, flush with used turbine test oil which had passed a rusting test, with the hope of providing an inhibitive coating on the parts. Then it was planned to rerun with a new charge of the same type of Navy oil. We had meanwhile examined eleven of the then available approved Navy oils and found that all except one failed to pass the rusting test. The one which did pass, unfortunately, was not immediately available. In view of the emergency, it was deemed unwise to take any further chances. Thus, in order to complete this important test program, with Navy permission, we procured an oil made specially for us from stock which had passed a rusting test, and carried the test to a successful conclusion. This oil was not Navy approved; it simply had the required viscosity characteristics, but probably would not have passed the Navy work-factor test.

Later, a supply of the Navy approved oil passing the rusting test was procured and used on all subsequent tests with no further rusting difficulties. This is an inhibited oil and is still being used. No further difficulties have been experienced to this date.

In shop tests where a light 150-sec oil is used, no rusting has been experienced with, we believe, two exceptions. This is due to the fact that such tests are generally run on "used" oil which does not allow rusting. Laboratory tests, however, have indicated that these oils in their new state are borderline, sometimes passing and at other times not passing the rusting test. Steps were taken some time ago to have our suppliers add an inhibitor to forestall any rusting should a new batch of oil be used. New oil probably caused the rusting previously mentioned. The same conditions apply to our heavier test oil (425 sec).

As a result of this procedure, we have for the past 6 years been entirely free from rusting difficulties in our shops from these two sources.

Later, rusting was experienced in our machine tools where highly refined oils were used and, as a result, we insisted that all such oils should be inhibited. Further troubles were elimi-

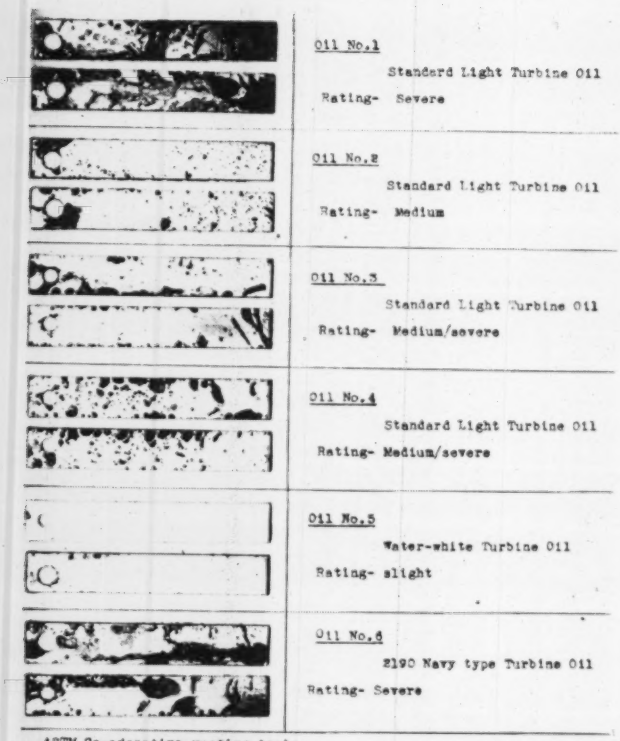

FIG. 2 TEST METHOD OF AUTHOR'S COMPANY AS SUBMITTED IN A.S.T.M. CO-OPERATIVE RUSTING TESTS

nated, and all oils used for this purpose must now pass a rusting test.

The author's company at that time issued an instruction bulletin on turbines, one section of which dealt with lubrication. With our investigations pointing to the cause of rusting in the field, certain stop-gap recommendations were issued. These included the addition of an old oil to the new oil, and also suggested that in the case of a new turbine installation, old oil from an existing turbine should be used in the new unit and that the new oil be placed in the old turbine unit. Several refiners approved of these temporary recommendations. While these suggestions were known to prevent rusting in the field, it was also realized the practices would tend to deteriorate the new oil quite rapidly, but in the emergency it appeared to be the most feasible solution. These recommendations were withdrawn as soon as it was demonstrated that satisfactory oils would be available from the refiners.

WORK OF A.S.T.M. COMMITTEE ON TURBINE OILS

We would now like to call attention to an A.S.T.M. committee, Technical Committee C of D-2, which was organized in 1940. A Subcommittee XI on Turbine Oils had functioned for some years, but was discontinued in 1938, when "there did not appear to be any additional work that should be undertaken by the subcommittee." In January, 1939, the author's company recommended to the American Society for Testing Materials that a new Subcommittee on Turbine Oils be established, and in June of that year an agreement was reached to form such a subcommittee, with the result that Technical Committee C was formally organized in January, 1940.

Two sections were instituted, Section I on Turbine Oiling Systems and Section II on Rusting Tests; the latter with the author as chairman, and refiner, user, and builder representative membership. The U. S. Navy Engineering Experimental Station is also represented.

At the March, 1940, meeting, a review of available methods of rust-testing was undertaken, and arrangements were made for the co-operative testing of six oil samples. The review indicated only two or three methods of test. In June, 1940, the first test results were submitted. Every co-operating laboratory reported; all were in substantial agreement, and all submitted photographs of their test specimens. Fig. 2 illustrates results of the author's company.

At this meeting, it was agreed to conduct future tests at elevated temperatures in order to simulate turbine-oil temperatures. During the next year, additional co-operative test work was carried on, and in October, 1940, the results appeared to indicate that the test developed by the author's company had the most possibilities. All through the activities of the section, most substantial agreement ensued and in June, 1941, it was decided to publish the so-called Westinghouse test for informative purposes, the modifications to include running at 140 F for 48 hr, instead of the five 8-hr periods at room temperature, and with 10 per cent water added instead of 1 per cent.

STANDARD TESTS DEVELOPED

In January, 1942, additional co-operative tests resulted in such close agreement that it was voted to recommend the presentation of the method to the society as a tentative standard. As an example of this close agreement on the part of the co-operators, a list of results is shown in Table 3. The descriptions under each oil are the co-operator's ratings.

TABLE 3 RESULTS OF RUSTING TESTS ON TURBINE OILS BY VARIOUS LABORATORIES

	Light oils, nos.			Heavy oils, nos.		
Laboratory	13	14	15	16	17	18
A	Severe	Very light	None	Severe	Few spots	None
B	Severe	Few spots	None	Heavy	Few spots	None
C	Severe	Traces	None	Heavy	Traces	None
D	Severe	Few Spots	None	Heavy	Traces	None
E	Severe	Few Spots	None	Severe	Slight	None
F	Severe	Light	None	Heavy	Light	None
G	Severe	Few spots	None	Heavy	Traces	None
H	Severe	Very light	None	Severe	Slight	None
I	Severe	Slight	None	Severe	Light	None
J	Severe	Slight	None	Severe	Slight	None
K	Severe	Slight	None	Severe	Light	None
L				Severe	Light	None
M				Severe	Light	None
N	Severe	Slight	None	Severe	Light	None

Oils

13 A new oil with which marked corrosion was experienced.
14 A borderline oil, permitting very little corrosion.
15 Definitely inhibits corrosion even in concentration of 10 per cent by volume in new corrosive oil.
16 2190 Navy type oil. Severe rusting experienced in service.
17 2190 Navy type oil. Occasional rusting experienced.
18 2190 Navy type oil. No rusting experienced in three years.

In June, 1942, the method was adopted as a tentative standard (D 665-42 T), and plans were made to continue co-operative tests and to investigate the possible use of round specimens. The committee had been organized exactly 2 years, and its membership was congratulated by the secretary of D-2 on the progress made. It was further stated that the "discovery" of the rusting problem together with the preparation of a rusting test was an important contribution to the petroleum industry.

In June, 1943, with an additional year of co-operative effort with round specimens, a further revision of the method was contemplated. This was to include the use of round specimens and some minor changes in procedure, yet basically the original

TABLE 4 RESULTS OF RUSTING TESTS ON TURBINE OILS USING ROUND SPECIMENS

Laboratory	Heavy oils, nos. 16	17	18
A	General	Traces	None
B	Heavy	Traces	None
D	Heavy	Traces	None
E	Severe	Slight	None
F	Heavy	Light	None
H	Severe	Light	None
J	Heavy	Slight	None
K	Severe	Light	None
L	Severe	Moderate	None

OILS

16 2190 Navy type oil. Severe rusting experienced in service.
17 2190 Navy type oil. Occasional rusting experienced.
18 2190 Navy type oil. No rusting experienced in 3 years.

test was retained. Again, as an indication of the close agreement between the several laboratories, Table 4 gives some results obtained on round specimens. Results of tests by the author's company are shown in Fig. 3.

METHOD REVISED FOR FINAL APPROVAL

In June, 1944, the method was revised (D 665–44T) to provide for the use of a $^1/_2$-in. round specimen. The method involves stirring a mixture of 300 ml of the oil under test with 30 ml of distilled water at approximately 1000 rpm and at a temperature of 140 F, with a round steel specimen immersed therein. After 48-hr contact with the oil-water mixture, the specimen is examined to determine whether or not it has rusted.

No doubt the method will be recommended for advance to standard in 1947. Meanwhile a possible reduction in testing time from 48 hr to 24 hr is to be investigated. Increased testing temperatures are also to be investigated. The section will also undertake setting up a test with synthetic sea water to be used in testing oils for use aboard ships.

This is the first time the author's company has publicly presented data on this most important question of rusting, although it required considerable restraint not to do so, especially in the early years, for the problem of eliminating rust was very serious and the results of the investigation most unusual and far reaching.

ACKNOWLEDGMENT

We desire to acknowledge the helpful suggestions of Mr. M. D. Baker, Chief Chemist, West Penn Power Company, during the early stages of the investigations. To the A.S.T.M. members, for their unstinting co-operation and understanding in making the work of the section a success, we express our thanks. Finally we thank our refiner friends who so kindly listened to our stories and who when they "saw the light" did something about it. Immediately taking hold of the problem, they in a very short while produced results. Present-day turbine oils are not only rust-resistant but definitely improved, in particular with respect to resistance to oxidation.

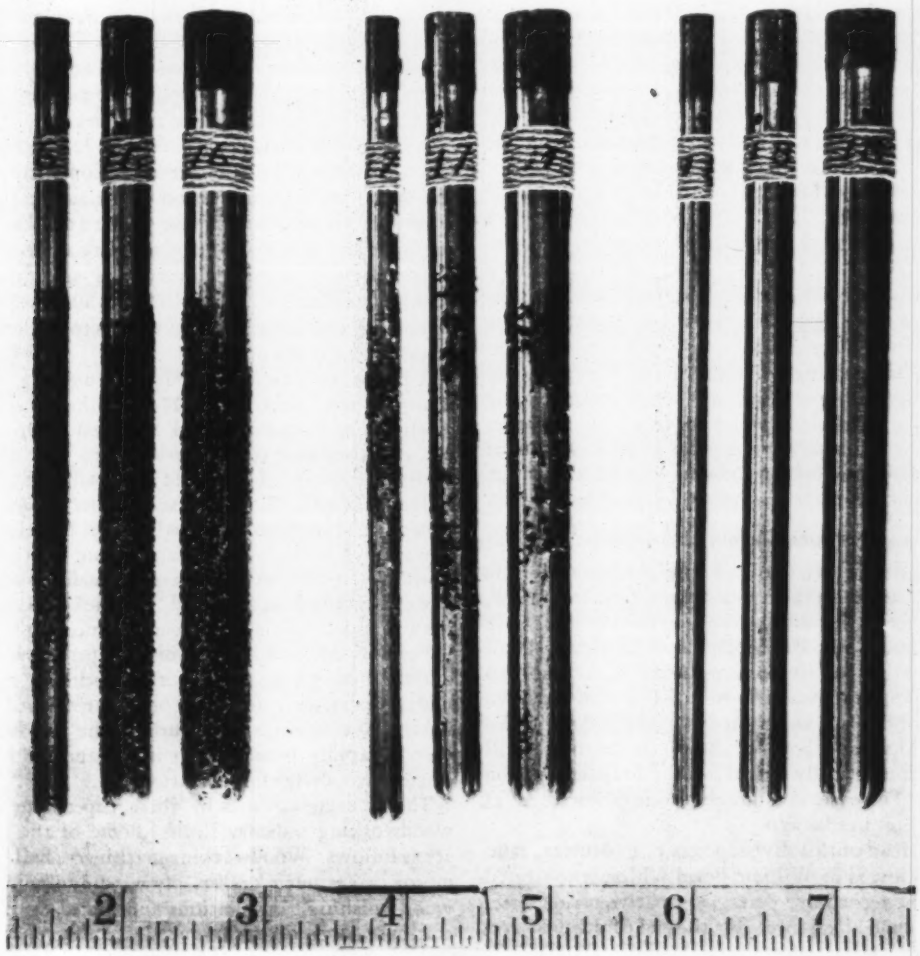

FIG. 3 RESULTS OF RUSTING WITH TURBINE OILS ON ROUND SPECIMENS

Record of the A.S.M.E.

WOOD INDUSTRIES DIVISION

A Quarter Century of Achievement

FIRST known as the Forest Products Division, the name of this branch of Society activities was changed in 1925 to the Wood Industries Division in order more or less to exclude paper, pulp, and other chemical wood-conversion projects whose interests were adequately served by other national technical associations.

The first bid of this division for public interest was an article, which appeared in this publication,[1] the editorial comment on which by the late editor, Lester G. French, contained the following statement:

"The woodworking industry is one of the greatest in this country and one in which it might appear that the engineer took a prominent part. Such, however, is quite contrary to the actual facts in the case, for this great industry is urgently in need of engineering skill of the highest type. With a view of outlining the scope of the woodworking field and presenting some of the engineering problems involved therein, Mr. Perry, vice-president and manager of The Grand Rapids Veneer Works, has prepared an article which appears in this issue. . . . ."

The closing paragraph of the comment is in a similar vein:

"The field for the engineer in woodworking is almost unlimited, but the development of such a new and untried line will take education, patience, and adaptability on the part of all who are vitally interested in the trades that employ so large a proportion of our citizens."

These fundamentals, stated a quarter of a century ago, are even more true today. Substantial progress has been made by engineers in the woodworking industries, but each step forward has uncovered more problems than it has solved, so that the work ahead is even more challenging today than it was in 1920. These original guiding principles have been the road map during these twenty-five years and engineers are giving evidence of a growing interest in woodworking. On the other hand, the military requirements of the great war recently ended have convinced the woodworking industry that only through applied engineering can the greatest progress be achieved.

EARLY PLANS OF FOREST PRODUCTS DIVISION

The first sessions of the then known Forest Products Division were held in connection with the Annual Meeting at New York, N. Y., in December, 1920, under the committee leadership of Thomas D. Perry, Grant B. Shipley, and Charles E. Paul. Mr. Shipley, through his connections with the Pittsburgh Wood Preserving Company, was able to supply five of the seven papers presented. Mr. Paul was a professor at the Armour Institute of Technology, and both of these gentlemen are still among us, although practically retired from active participation in Society affairs. The early committee meetings were held at the Auditorium Hotel in Chicago.

The second chairman of this division was F. F. Murray, who served one year, followed by William Braid White, who steered its course during the second five years, a formative period, after the initial momentum had lessened. At the end of this first decade the division had become well established, and its subsequent officers are given in the accompanying list of the members of the executive committees.

[1] "The Engineer and the Woodworking Industry," by T. D. Perry, MECHANICAL ENGINEERING, vol. 42, 1920, p. 448.

PRESENT ORGANIZATION OF DIVISION

After trying out several methods of committee appointments, the following procedure has proved to be very satisfactory: A five-year member is added each year to the executive committee, who works up to the chairmanship in his final year, and on his retirement becomes the junior member of the advisory committee, where he serves another five years. The general committee is composed of nine members, three for three years each. They are usually chosen to represent diversified products, because of earnest co-operation or to establish local contacts.

A considerable number of subcommittees have undertaken special tasks such as wood-finishing studies, dimensional tolerances, plywood research, saws and knives, machining of wood, etc. The latest project in this direction is the Forest Protection Committee, a joint activity with the Society of American Foresters, to promote the development of more efficient mechanical fire-fighting equipment in the forest areas.

It is perhaps worthy of note that 125 man-years have been given to the work of the executive committee by members of the Wood Industries Division. The subjective and objective effects of this work are far too great to calculate. Woodworking is a vast industry and engineers are a potent leaven.

The division has met every year since its inception and achieved an all-time high in 1928 and 1930, when four meetings were held, including those of the Metropolitan Section in the Greater New York area.

A list of the locations and dates of meeting is also appended. Many of these meetings (1927–1939) have been held as exclusively Wood Sessions (called National WDI meeting) in various woodworking centers, in order to keep in closer contact with the industry than would be possible at Annual Meetings in New York, N. Y. Other sessions have been held in connection with Spring, Semi-Annual, or Fall Meetings of the Society at various locations. This latter plan, if proper locations are available, works out most satisfactorily, since it provides a more diversified background for the woodworking sessions than is possible for a single-purpose meeting.

Between 200 and 250 technical papers have been presented, during these years, most of them printed, which have been widely distributed, and many of them reprinted. They form the nucleus of a technical literature for the woodworking industry that is rapidly becoming an important contribution to more efficient woodworking operations.

The subjects covered by these papers are as broad as the woodworking industry itself. Some of the major groupings are as follows: Woodworking machinery, ball bearings, cutters, motor drives, etc; veneer, plywood and adhesive operations; wood finishing, formulations and forced drying; abrasive operations; dry-kiln technique; assembly operations; logging and sawmills; characteristics of different wood species; impregnating and fireproofing; fire-fighting equipment. Quite a

number of these papers have been combined in printed publications, such as the following:

Report on Wood Waste Reduction (1928): Requirements for improved design in saws and knives.

Symposium on Glues for Wood Products (1932): Seven papers on glues and gluing technique.

Symposium on Wood Preservatives (1933): Eight papers on preservative treatment of lumber.

Report of Committee on Wood Finishing (1941): Recommended practices in the preparation of wood surfaces.

Bulletin of papers (7), contributed for the 1944 meeting at Cincinnati, canceled at the request of the Office of Defense Transportation.

Bibliographies: *Woods of the World* 1928; *Machining of Wood* 1929; *Aircraft Plywood* 1944 (joint with Aviation Division).

Other papers presented at sessions of the Wood Industries Division have been extensively reprinted privately and distributed by a number of industrial companies.

EXECUTIVE COMMITTEES OF THE WOOD INDUSTRIES DIVISION

1920	T. D. Perry[a]	1935	G. R. Petrie[a]
to	G. B. Shipley[b]		A. W. Keuffel[b]
1922	C. E. Paul		L. M. Nichols
1923	T. D. Perry[a]		A. D. Smith, Jr.
	G. B. Shipley		H. B. Carpenter
	C. E. Paul	1936	H. B. Carpenter[a]
	H. C. Rice		L. M. Nichols[b]
	W. H. Coye[c]		G. R. Petrie
1924	F. F. Murray[a]		R. H. McCarthy
	H. C. Rice[b]		A. W. Keuffel
	T. D. Perry	1937	A. W. Keuffel[a]
	G. B. Shipley	to	L. M. Nichols[b]
	W. H. Coye[c]	1938	R. H. McCarthy
1925	W. B. White[a]		P. T. Norton, Jr.
	F. F. Murray		T. D. Perry
	G. B. Shipley	1939	R. H. McCarthy[a]
	C. M. Bigelow		P. T. Norton, Jr.[b]
	P. H. Bilhuber		A. W. Keuffel
1926	W. B. White[a]		T. D. Perry
	P. H. Bilhuber[b]		C. B. Norris
	T. W. McNeill	1940	C. B. Norris[a]
	J. S. Mathewson		M. J. MacDonald
	Sern Madsen[c]		T. D. Perry
1927	W. B. White[a]		Sern Madsen[c]
	P. H. Bilhuber[b]	1941	C. B. Norris[a]
	T. W. McNeill		M. J. MacDonald
	J. S. Mathewson		T. D. Perry
	T. D. Perry		D. R. Gray
	Sern Madsen[c]		Sern Madsen[c]
1928	W. B. White[a]	1942	T. D. Perry[d]
to	C. L. Babcock[b]		A. C. Fegel[b]
1929	T. D. Perry		M. J. MacDonald
	J. S. Mathewson		D. R. Gray
	A. S. Kurkjian		Sern Madsen[c]
1930	T. D. Perry[a]	1943	Sern Madsen[a,c]
to	C. L. Babcock[b]		A. C. Fegel[b]
1931	A. D. Smith, Jr.		M. J. MacDonald
	A. S. Kurkjian		D. R. Gray
	R. K. Merrill		H. S. Jones
1932	C. L. Babcock[a]	1944	M. J. MacDonald[a]
	A. D. Smith, Jr.		A. C. Fegel[b]
	A. S. Kurkjian		D. R. Gray
	R. K. Merrill		H. S. Jones
	H. B. Carpenter		F. J. Hanrahan
1933	A. D. Smith, Jr.[a]	1945	D. R. Gray[a]
	H. B. Carpenter[b]		A. C. Fegel[b]
	C. L. Babcock		C. R. Nichols, Jr.[b]
	A. S. Kurkjian		C. B. Lundstrom
	G. R. Petrie		F. J. Hanrahan
1934	A. D. Smith, Jr.[a]		E. D. May
	H. B. Carpenter[b]	1946	A. C. Fegel[a]
	A. S. Kurkjian		C. B. Lundstrom
	G. R. Petrie		F. J. Hanrahan
	L. M. Nichols		E. D. May
	C. L. Babcock		

[a] Chairman; [b] Secretary; [c] Deceased; [d] Acting chairman.

The membership of the division has never been large, between 500 and 600, but its committees have been active, aggressive, and persistent. There is no doubt but that this cooperative effort has been of lasting and material benefit both to engineers of the A.S.M.E. as well as to woodworkers, and each owes a distinct debt of gratitude to the other. The sponsorship of the A.S.M.E. has established the project on a much broader and firmer basis than would have been possible if the technical activities had been limited to those that could be initiated and carried out within the woodworking industry itself. In that way the engineering fraternity has been able to spread the gospel of more efficient wood-product production.

With the past twenty-five years as a foundation, the next quarter century should be far more fruitful in co-operative achievements between engineers and woodworkers. It is not too much to hope that during this period the woodworking industries may become outstanding, among other major industries, for their accomplishments in applied engineering.

MEETINGS HELD BY FOREST PRODUCTS DIVISION

1920	December	New York, N. Y.	Annual
1921	December	New York, N. Y.	Annual
1922	December	New York, N. Y.	Annual
1923	December	New York, N. Y.	Annual
1924	December	New York, N. Y.	Annual
1925	May	Milwaukee, Wis.	Spring
	December	New York, N. Y.	Annual

MEETINGS HELD BY WOOD INDUSTRIES DIVISION

1926	May	Providence, R. I.	Spring
	November	Chicago, Ill.	
	December	New York, N. Y.	Annual
1927	May	White Sulphur Springs, W. Va.	Spring
	August	Seattle, Wash.	
	October	Grand Rapids, Mich.	First National WDI
1928	February	New York, N. Y.	Metropolitan
	October	Boston, Mass.	N. E. Industries
	November	Grand Rapids, Mich.	Third National WDI
	December	New York, N. Y.	Annual
1929	May	Rochester, N. Y.	Spring
	October	Rockford, Ill.	Fourth National WDI
	December	New York, N. Y.	Annual
1930	February	New York, N. Y.	Metropolitan
	June	Detroit, Mich.	Semi-Annual
	October	New York, N. Y.	Fifth National WDI
	December	New York, N. Y.	Annual
1931	October	Winston-Salem, N. C.	Sixth National WDI
1932	November	Jamestown, N. Y.	Seventh National WDI
1933	March	New York, N. Y.	Metropolitan
	June	Chicago, Ill.	Semi-Annual
1934	October	Camden, N. J.	Ninth National WDI
1935	June	Cincinnati, Ohio	Semi-Annual
1936	September	Niagara Falls, N. Y.	Fall
1937	October	Grand Rapids, Mich.	Tenth National WDI
1938	September	High Point, N. C.	Eleventh National WDI
1939	October	Boston, Mass.	Twelfth National WDI
1940	February	New York, N. Y.	Metropolitan
	September	Spokane, Wash.	Fall
1941	February	New York, N. Y.	Metropolitan
	October	Louisville, Ky.	Fall
1942	October	Rochester, N. Y.	Fall
1943	April	Davenport, Iowa	Spring
	December	New York, N. Y.	Annual
1944	October	Cincinnati, Ohio	Fall[e]
	November	New York, N. Y.	Annual
1945	November	New York, N. Y.	Annual
1946	October	Boston, Mass.	Fall
	December	New York, N. Y.	Annual

[e] Canceled by O.D.T.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Atom Bomb Vs. Ships

THE effect the atomic bomb will have in changing surface vessel design and tactical concepts is detailed by Philip W. Swain, member A.S.M.E., editor, *Power*, in the August, 1946, issue of *Aviation*. Mr. Swain was attached to the Navy press ship *Appalachian* which moved in quickly for a first-hand survey of the bombing results. As Mr. Swain is an atomic-energy authority it is felt that the following comments by him on the Bikini "Able Day" test will prove interesting:

The Able Day experiment was well planned and executed. The bomb was of normal efficiency and performed as informed opinion had predicted. Those who expected the impossible—trees uprooted at Bikini Island three miles away or steel melted on ships a quarter-mile away—were disappointed.

Such unscientific expectations arose largely from failure to understand how rapidly all bomb effects must fade with distance. The much advertised "100,000,000-deg heat" was confined to the bomb's center and lasted perhaps a millionth of a second. This dazzling photoflash didn't melt even the thinnest aluminum foil or appreciably warm the ships. It merely gave them a skin-deep sunburn. Top paint coats were blistered; lower coats were untouched.

Very likely the instantaneous pressure at the center of the bomb reached millions of pounds per square inch, but again distance did its work. On the cruiser *Pensacola*, approximately one-third mile from the burst, blast pressure was only 5 or 10 psi, which would be enough to account for the collapse of the approximately 20-ft wide × 30-ft high funnels of thin-gage steel. At 10 psi the total force on the projected area of one stack would be over 400 tons.

The bomb produced approximately the same blast, flash, and radioactivity as the one that burst over Nagasaki. But the much stronger construction of naval targets contracted the circle of great damage from about a 3-mi diameter to about $1\frac{1}{2}$ mi. Moreover, the space within the smaller circle was mostly open water, not a solid mass of structures as in a city.

Atom-bombing a fleet is something like atom-bombing a community of small farms where each farm house (ship) is heavily built of reinforced concrete.

Before this test it was obvious that a fleet could be so disposed that no atom bomb could sink more than one ship. Now admirals will know just what spacing of ships at anchor or in motion will achieve this one-bomb per ship situation for ships of given type and construction.

The position and height of the burst will not be revealed, but guessing is permitted. From my observation of flash shadows, I estimate that the burst was 400 to 600 ft in the air, about 1200 ft astern of the *Nevada* and slightly on the port side.

All the damaged ships inspected showed the effect of a moderate blast pressure rather evenly spread over vast areas. Heavy structures, such as big funnels and turrets, were unscathed. More flimsy constructions, such as thin windbreaks, funnels, topmasts, and radio masts, were often bent and twisted. At one-third mile, or even less, rubber tires remained like new and exposed jeeps could have been driven away. On the other hand, many airplanes on decks at greater distances were substantially damaged by blast pressure. Lest all this sounds like belittling the Able Day bomb, let me point out that it did immensely more damage than any other in naval history; that it sank five ships, heavily damaged five others.

Of the unsunk ships, only the *Independence* showed any hull damage, and that well above the water line. She was thoroughly smashed topside. Damage to the heavily built *Nevada* was all topside and moderate. Heavy construction was not affected. Thinner plates exposed to the blast and not well braced were often bent or loosened. On ships within $\frac{1}{2}$ mile, topmasts, radio masts, and funnels were often damaged.

Considering material damage to the ships as distinct from the effect of radioactivity on life aboard, I would assess the damage to well-built warships from an air blast of this type about as follows in terms of distance from the blast: 1 mi, practically no damage; $\frac{3}{4}$ mi, slight damage; $\frac{1}{2}$ mi, moderate damage; $\frac{1}{4}$ mi, heavy damage; somewhere between $\frac{3}{16}$ and $\frac{1}{8}$ mi, sinking. There appears to be little hull damage beyond $\frac{1}{4}$ mi.

As to the protection of the men aboard ships, I would expect special clothing could protect the crew from injury by heat flash wherever distance would save the ship and crew from the blast. I dare not assume that similar protection can be provided against radioactivity. There the difficulties are great and no final answer can be given until the reactions of the experimental animals have been fully studied.

Men on ships exposed to atom bombs would receive tremendous doses of radioactive rays, including the penetrating gamma rays that retain 10 per cent of their strength even after traversing 2 in. of solid steel. Moreover, the immediate survivors of the blast would be living in a radioactive ship where even the table salt, the food, and the soap would be dangerously radioactive. Careful, long-term observation of the exposed animals can show at what distance ships' crews exposed to radiation might be permanently safe, and at what short distance they might live to finish a battle, although as men marked for certain death.

It is clearly impracticable to design a ship or protect a crew for survival under direct hit or near miss of an atomic bomb. But the Navy must soon decide for each class of ship what is the survival distance for the ship and crew as an operating unit. Such studies will inevitably lead to marked changes in ship design and operation.

Some have said the tests are a waste of money because a navy will be useless in an atomic war, since rockets can attack directly across oceans. Personally, I don't think the time has yet come to junk the Navy.

But two facts have now been clearly demonstrated: The atomic bomb (and rocket) is the most effective weapon ever devised against ships. It is even more effective for the area bombing of cities and of concentrated industrial areas. The kind of bomb that failed to rip the leaves from the palms of Bikini Island can still destroy civilization if atomic war comes.

Supersonic Airplane

THE first pilot-carrying airplane designed to travel faster than sound has been built for the National Advisory Committee for Aeronautics as a research tool to probe the realm of supersonic flight not yet penetrated by man. The XS-1 has been constructed by Bell Aircraft Corporation under contract to the Army Air Forces, and is based on high-speed design information provided by the N.A.C.A., according to specifications worked out among the N.A.C.A., the A.A.F., and Bell. The airplane has already been flown in unpowered glide tests, and is to make the first rocket-powered flights this fall.

The Bell XS-1 is completely instrumented by N.A.C.A. research engineers to obtain new and unknown facts on flight through and above the speed of sound. The original contract provides for the airplane to be built for the A.A.F., acting in its capacity of specifying and procuring agent. The airplane is to be acceptance-tested by the manufacturer to meet certain specifications of performance and handling up to a speed limit of 80 per cent of the speed of sound, or about 612 mph at standard sea-level temperature. At this point the XS-1 is to be turned over to the N.A.C.A. for flight research up to 120 per cent of the speed of sound or beyond, if possible.

Just how fast the XS-1 will be able to fly will probably depend on how the controls react near the speed of sound. This, rather than the drag and thrust that can be calculated, constitutes the real unknown. The "transonic" region, from about 80 per cent to 120 per cent of the speed of sound, is difficult to duplicate in a wind tunnel, due to shock waves that "choke" the tunnel. N.A.C.A. wind tunnels have provided accurate information up to 96 per cent of the speed of sound, and this indicates that the XS-1 will encounter rapid and severe changes in control characteristics.

When the airplane has been flown up to its safe upper limit of speed and the desired records have been gathered, the XS-1 will be turned over to the A.A.F. for further experiment as they see fit. The knowledge gained will be incorporated in subsequent designs to carry the quest to still higher speeds.

The original contract specified a climb to 35,000 ft, with level flight carried on from there. Plans by Bell and the A.A.F. indicate that the XS-1 may be taken up to 35,000 ft by a B-29 and released to shoot up to still higher altitudes to achieve greater speed. Since rockets do not depend on oxygen in the air, power does not diminish with altitude as is the case with ordinary engines. With the lessened resistance of rarefied air, greater speed can be attained. Tests may be carried out at the A.A.F.'s test field at Muroc Lake, California.

Collapsible Tubes

ONE of the most commonplace metal products used in this country is the collapsible tube, according to an article by Frank T. Sisco, in *Mining and Metallurgy*, August, 1946. Strangely enough, writes Mr. Sisco, few engineers know anything about its manufacture or about the materials used for this container that holds shaving soap, tooth paste, cold cream, adhesive paste, and glue, and hundreds of other semiliquid substances that must be dispensed cheaply, safely, cleanly, and in small quantities.

Collapsible tubes are an almost ideal container for semiliquid materials: they are leakproof, they have a high ductility and enough strength to be fabricated and filled cheaply by automatic or semiautomatic machinery, they can be used roughly without premature failure, they are attractive in appearance, and a decorative finish can be economically applied. In addition, they can be made to close dimensional tolerances and there is a low scrap loss in manufacture; moreover, the scrap that is produced has a relatively high recovery value.

Tin and lead are the principal metals used for collapsible tubes. Before the war approximately 6 per cent (3500 to 4000 tons) of the total tin consumption in the United States was used for the millions of collapsible tubes produced annually. Most of these were drawn from the unalloyed metal or, if exceptional stiffness was required, from an alloy of tin containing a small amount (less than 1 per cent) of bismuth or copper. Tin is undoubtedly the most attractive metal for tubes to be used in the household because of its bright color and its resistance to tarnish and to corrosion by the ingredients used in toilet creams and cosmetics.

Shortages of tin during the war made it necessary to restrict the use of this metal to certain types of bearings and tin plate; consequently, no collapsible tubes of tin—except small containers for a few drugs—have been made since 1941. The substitute was lead or an alloy of lead and a small amount of antimony or other stiffening material. Lead is readily fabricated into tubes and it is highly corrosion-resistant in many environments, but it is not so resistant as tin to a number of the ingredients used in toilet preparations and similar products. It was necessary therefore to lacquer and in some cases to tin-coat the inside of the tube.

Collapsible tubes and a few other products—particularly those known as shells—are made by impact extrusion. Round slugs of the required thickness are punched from sheet or strip or, if extremely large tubes are made, the slugs are cut from bars. These slugs are inserted in a die in a crank-type press, and the tube is formed by one blow of a punch. Depending on the metal being fabricated, pressures necessary to form the tubes vary from about 50,000 to as much as 200,000 psi. Manufacture of the finished tube is almost entirely automatic; this includes trimming, threading, and applying paint or lacquer externally and, if necessary, internally. After these operations are completed, the tubes are baked; this is followed by the final operation of printing or lithographing. On tubes smaller than about 2 in. in diameter production speeds vary from 30 to 70 tubes a minute. Labor cost is low.

The other two metals—aluminum and zinc—that can be readily fabricated by impact extrusion are seldom used for collapsible tubes; they are, however, widely used for shells or cups, the names applied to the tubular or cup-shaped cases for dry-cell batteries, flashlight cases, cans for radio condensers, transformer and radio-tube shields, fire-extinguisher parts, and for many other similar products.

Plastic Bearings

UNIQUE experiment with transparent plastic models of machine bearings are revealing information that may result in more powerful motors for the nation's factories, research engineers of the Westinghouse Electric Corporation disclosed recently.

The plastic models are enabling scientists to look inside a moving bearing and see what is happening to the lubricating oil—something never before possible, according to John Boyd, research engineer who developed the novel technique.

Examination of these plastic models in operation often is better than weeks of mathematical calculations. Guesswork is eliminated. Now engineers can see what is happening and can design bearings which will handle a heavier load and help make possible more powerful motors without any increase in size or weight.

The procedure is simple. Oil, colored with a red pigment, is

FIG. 1 TRANSPARENT MACHINE BEARINGS GIVE ENGINEERS INSIDE LOOK

fed into the bearing model and the lubrication effectiveness quickly is apparent. Engineers know at once whether the seals work properly, whether the oil passages are enabling a proper flow of the lubricant, and whether the relief points are located correctly. All this formerly had to be determined largely by trial and error.

Blocks of lucite are machined to close tolerances just like metal to form the models of bearings and journals. During the actual operating tests the rotating element of the finished model is operated by a hand crank for slow speeds and is motor-driven for high speeds.

As the red-colored oil works its way through the bearing, engineers can see whether the grooves which distribute the oil are properly placed to do a thorough job. If these oil passages are not in the right position, some areas will be starved for oil and the bearing cannot carry a full load. This, in turn, reduces the amount of work which the motor can handle.

Welding Aluminum

GAS welding, arc welding, resistance welding, brazing, and soldering are the principal subjects covered in Reynolds Metals new 88-page book devoted to bringing to users of aluminum a comprehensive résumé of the latest practices and recommendations for joining aluminum by these processes.

After a brief discussion of the more widely used aluminum alloys from the standpoint of factors affecting their weldability, the book analyzes recommended gas-welding practice with sections covering such topics as edge preparation; cleaning and preheating; the welding flame; welding rods, fluxes, and technique.

The arc-welding material includes chapters on the metal-arc, carbon-arc, atomic-hydrogen, and inert-gas-shielded processes. Resistance welding is broken down into sections on spot welding by four different methods; seam and flash welding, with information on preweld cleaning, recommended machine settings, tip pickup, and where to look to correct trouble. Subsequent chapters discuss furnace and torch brazing, soldering, inspection of welds, and metallurgy of welds.

The book is available from Reynolds Metals Company, Department 47, 2500 South Third Street, Louisville 1, Ky.

Plastic-Aluminum Houses

PLASTIC-ALUMINUM houses, quickly constructed but exceedingly strong, are a reality according to the expanded structural plastic development of Lincoln Houses Corporation, New York, N. Y. Consisting of resin-impregnated paper cellular core, faced with aluminum sheets, Fig. 2, this material may play an important part in carrying out the government's program of 2,700,000 new homes within two years. At present model homes of this construction have undergone tests which indicate their extreme livability. A description of the houses appears in the July, 1946, issue of the *Bakelite Review*.

Any floor plan or design is possible; however, the forerunners of homes to come are built with five and nine rooms. The five-room house has a total weight of only one ton as compared with forty tons of material used in a conventional five-room house. Not a temporary structure, the houses have concrete-block foundations which rest on a moisture-resistant and heat-retaining vaporproof material. Concrete poured over a metal grillwork then serves as the flooring, while expanded structural laminated panels, eight feet long and four feet wide, are set into place. These panels, two inches thick for the walls and three inches thick for the roof, are joined to each other by metal screws inserted with an ordinary screw driver. The panels, once in place, weld themselves more tightly together through the adhesive qualities of the resin-treated plastic filler. Thus in a few days the screws could be removed altogether since the house has become a single-fast-joined unit. This panel construction is extremely valuable since it acts as insulation against both heat and cold. Exhaustive tests made by the company revealed that no moisture collects in the panel, thus preventing condensation on the interior of the panel structure. Tests conducted by independent laboratories show the breaking loads in bending to be equivalent to a uniformly distributed force of 125 lb per sq ft on a wall panel 8 ft high. It is also computed from results of bending and column tests that a wall of this construction 8 ft high would carry a vertical load of at least

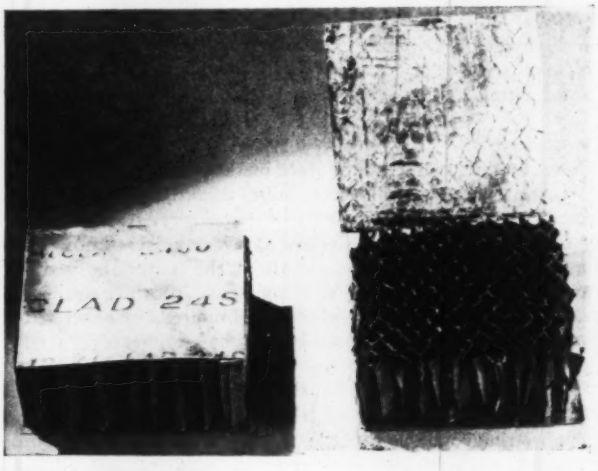

FIG. 2 A SMALL SECTION OF THE EXPANDED STRUCTURE WITH ALUMINUM SHEET SHEARED AWAY FROM THE CORE

5000 lb per linear foot. In the layman's language, this compares favorably with the load-carrying capacity of a brick wall 8 ft in height and one foot thick.

Paint of any desired color can be baked on the panels at the factory, just as is done with automobiles, so that washing the house will be no more complicated than car washing; or exterior walls could be waxed, just as automobiles, preserving the paint for years.

Doors made of the same panels weigh only seven pounds. They are covered with a thin wood veneer giving them a natural, solid-wood appearance, but at the same time retaining strength and light weight. Windows at the front and sides of the houses are built into the panels and those at the rear open outward on metal slides.

The house contains no cellar. Radiant heating is supplied by piping laid between the concrete floor and the dirt-covered, vaporproof material below. This removes the possibility of dampness forming in or under the floor. Small registers are placed strategically to permit warm air to rise into the rooms and no heating pipes are required. Heating source is an oil-burning unit.

Air Engines

AROUND the middle of the last century considerable interest was shown for a time in the air engine, but this was quickly supplanted by the development of internal-combustion engines. This was not due to the thermodynamic process involved, but to the technical constructions possible in those times. Recent research work in Philips laboratories has now shown that satisfactory results can be attained with air engines if they are built in accordance with modern conceptions with regard to heat transfer, flow resistance, properties of materials, etc. In an article appearing in the May, 1946, issue of the *Philips Technical Review*, H. Rinia and F. K. Du Pré discuss the theoretical principles of the air process. However, many of the technical data in the article, other than a description of the principle of the air engine, are omitted from this review.

The principle of the air engine can be explained with the aid of a much simplified model. Imagine a cylinder divided into two parts in open connection with each other. One part, the so-called hot space, is kept at the high temperature T_h by means of a heater, while the other part, the cold space, is kept at a low temperature T_c by a cooler. In each of the two parts

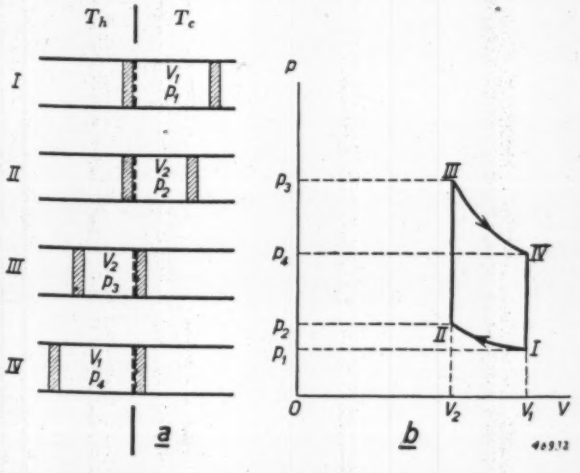

FIG. 3 DIAGRAM EXPLAINING THE ACTION OF AN AIR ENGINE

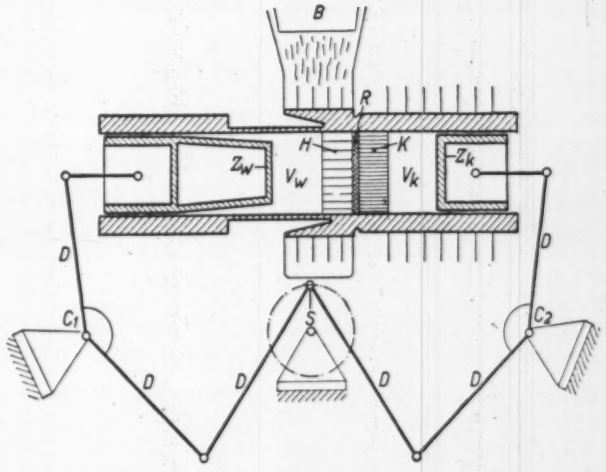

FIG. 4 DIAGRAM OF THE COUPLING OF THE TWO PISTONS OF THE AIR ENGINE

(V_w hot space, V_k cold space, Z_w hot piston, Z_k cold piston, D driving mechanism, C_1 and C_2 fixed pivots, S crankshaft, B burner. In the figure heater H, regenerator R, and cooler K, are also indicated.)

of the cylinder is a moving piston. A certain quantity of air is enclosed between the two pistons. We shall assume for the present that the transfer of heat between the cylinder and the air in it is so good that the air in the hot space is always at the temperature T_h and that in the cold space always at the temperature T_c.

We now cause the air in the cylinder to pass through a cycle consisting of four phases. The four positions of the pistons at the moments when one phase passes over into the next are shown in Fig. 3*a* as I to IV. The cycle is as follows:

At position I all the air is in the cold space, which has the maximum volume V_1.

The transition I–II takes place isothermally, according to our assumption about heat transfer; the air is compressed to the volume V_2.

At position II all the air is still in the cold space, which, however, now has the minimum volume V_2.

The transition II–III takes place at constant (minimum) volume. The air is displaced from the cold to the hot space.

At position III all the air is in the hot space, which has the minimum volume V_2.

The transition III–IV again takes place isothermally; the air expands from the minimum volume V_2 to the maximum volume V_1.

At position IV all the air is in the hot space, but this now has the maximum volume V_1.

The transition IV–I again takes place at constant (maximum) volume, the air being again displaced to the cold space.

It is not difficult to see that the process outlined can in principle be applied for an engine.

In the transitions II–III, and IV–I no mechanical work at all is done. The work which has to be supplied to the one piston is exactly the same as the work done by the other (all mechanical friction being disregarded of course), because the volume of the air remains constant during these transitions. Therefore we need only consider the transitions I–II and III–IV. The first is a compression and thus work must be done. This compression, however, takes place at a low temperature and therefore also at a low pressure. The second is an expansion and thus produces work. Since this takes place at a high temperature (and because the same series of volume changes takes place as in the compression, although in reverse order) the average pressure

is higher than in the compression and the work produced is greater than the work required for the compression. As a result there is a surplus of work per complete cycle.

The action of engines with one piston per cylinder usually consists in the piston being displaced during one half of a revolution under the influence of a high pressure and then moving back again during the succeeding half revolution against a lower pressure. In the presently described construction of the air engine this process is divided between two pistons, and between the two processes there is each time a workless phase. Otherwise the situation is quite analogous. In Fig. 3*b* the *p-V* diagram is drawn for the cycle outlined; the phases just described can easily be recognized. The work gained per cycle is represented in the diagram by the area of the curvilinear quadrilateral I–II–III–IV.

From the foregoing it is evident that the surplus of work is obtained owing to the fact that the isothermal expansion of the air takes place at a high temperature and the isothermal compression at a low temperature. This is one of the fundamental principles of the air engine and further use will be made of it in the future.

The cyclic process as described is of course in that form very difficult of realization technically; the four-phase piston movements would lead to very complicated constructions. It can, however, be so modified while still retaining the principle as to make it technically possible of achievement. Now imagine the two pistons as being coupled by a combination of driving rods in such a way that the movements of the hot piston are followed, with a certain phase difference, by those of the cold piston. In Fig. 4 a schematic representation is given of how that can be done. With this form of construction it is no longer possible to distinguish the separate phases as they begin to overlap somewhat, and in particular the expansion does not take place completely in the hot space nor the compression completely in the cold space. However, when the phase difference is suitably chosen, that is, in the neighborhood of 90 deg, it can be shown that the expansion does take place mainly in the hot space and the compression mainly in the cold space, so that this new cyclic process will also furnish a surplus of work per cycle, in this case per revolution of the crankshaft.

Mechanized Agriculture

THE impact of mechanization on agriculture during the recent war was discussed in a paper presented before the International Technical Congress, Paris, France, September, 1946, by Arthur W. Turner, assistant chief in charge of agricultural engineering research, Bureau of Plant Industries, Soils and Agricultural Engineering, U. S. Department of Agriculture.

Mechanization—or rather engineering advancement—in agriculture has been a most important factor in enabling the United States and Canada not only to avoid food shortages but also to produce surpluses. The beginning of machine farming in the United States dates back a little more than a century. During this time tremendous commercial and scientific advancements have been made. Mechanization began with the invention of farm machines to do the jobs formerly done laboriously by hand. A few are: the Manning mower and the McCormick reaper in 1831, followed by the steel plows of John Lane and John Deere in 1833–1837; and the Pitts threshing machine in 1837.

As a result of those and many other machines that have followed them, in 1944 and 1945 a rural population of less than 25 million people established an all-time record in producing more food and clothing materials than have ever been produced in any similar period in the world's history. That comparatively small farm population provided more food for the civilian population of 140 million people than the 1935–1940 average, and in addition exported nearly a quarter of the entire farm output to the armed forces and allies overseas. Now in 1946 and 1947, for the sake of world-wide humanity, farmers in America have been asked to exceed their previous production records.

Here is what is involved in food production, storage, transportation, and utilization: (1) Conservation of the topsoil—on which the very life of the world depends; (2) field crop-production equipment, from that needed in seedbed preparation, including proper fertilizer placement, to harvesting; (3) controlling and providing, through drainage and irrigation, proper moisture for crops, orchards, and pastures; (4) farm storage facilities so commodities can be stored safely either for farm feeding or year-round marketing at the growers' convenience rather than having to be sold on a flooded harvest market; (5) transportation of farm commodities from producer to consumer with minimum loss in quantity and quality; (6) shelter for farm animals to maintain their health, increase production, and conserve the farmers' chore time; (7) adequate farm utilities and housing, for in the farmhouse are combined the farmer's living quarters, his business headquarters, and sometimes his food-processing operations; (8) controlling plant and animal pests and diseases for maximum production; (9) partial processing of farm commodities so portions with commercial value only are transported from the farm to market; (10) application of electrical energy either as power, light, or heat for farm efficiency, health, and sanitation.

In all these phases of farming there are engineering applications.

Agriculture is the largest industry in America. It is a large user of power, labor, and materials. Prior to the war American industry had 50 million horsepower available, while agriculture had 97 million. The 1940 census reported 18.45 per cent of all persons gainfully employed to be in agriculture as compared to 24.3 in all of manufacturing. In materials American agriculture purchases one third of a billion dollars' worth of building materials annually, more than three fourths of a billion dollars' worth of machinery and equipment, and over half of a million dollars' worth of fertilizer. The immediate and potential consumption of electricity by agriculture is enormous. Now transmission lines provide power for more than three million separate farm industries. Agriculture in America is a big business and as such deserves a goodly number of specially trained engineers.

Agricultural engineering in its broad sense and in detail has been applying management to agriculture. Recently in a national meeting, two deans of agriculture in large state universities stated that after studying the activity of the agricultural engineering and the agricultural subject-matter groups, they were recommending that farm management be transferred from farm economics to agricultural engineering.

One of the major objectives of agricultural engineers in all the years since the mower and the reaper were invented has been to shift the burden of farm work from the worker to the machine. This will continue to be an objective, for it is only by reducing labor costs that the prices of food to consumers can be kept at low levels. Reductions in labor requirements and replacement of horses and mules with tractors which do not require grains and hay have been of major importance in keeping down food costs during these last few years and in previous years may also have contributed to our surpluses. The replacement of animal power alone has been equivalent to the addition of many thousands of acres of fertile land to our productive capacity.

Recognizing that there is a need for increasing food production throughout the world, there must be a need for more agricul-

tural engineers. What background and training should a food-production engineer have? First, he must be an engineer because he deals with power, labor, and materials. He must also know farming and the problems of crops and livestock production, processing, and marketing. In other words, he must know agricultural fundamentals.

The knowledge of buildings is important. Buildings represent a large part of the farmer's capital investment and affect his income in several ways. Where climatic conditions are unfavorable the amount of milk or eggs that a farm produces is likely to depend on the capacity or the convenience of the buildings. Storage buildings are also important because they affect the quality of the product when marketed and prevent losses after harvest.

Conserving and utilizing our agricultural lands, that is, draining excess water, adding needed moisture through irrigation, adapting the land contour to provide soil conservation, and controlling water action to prevent erosion and flood, requires basic training in hydraulics and agriculture.

Electricity is now on the farm. The job of proper rural electrification is not finished when all farmers who wish electric service have it. The principal objective is to get electric power efficiently applied to as many farm jobs as possible in ways that are profitable to the farmers. In order to do this properly each company needs a number of properly trained men who understand farming and who understand the application of electricity to farm operations.

The training of the agricultural engineer has the same relationship to agriculture as that of the mining engineer to mining and the aeronautical engineer to aeronautics. It is an engineering profession serving the agricultural industry. That industry, in many of its phases, calls for the highest type of engineering, a far advancement from its early beginning as farm mechanics. Its true importance stands out in bold relief.

Japanese Foundry Industry

AN article in the June, 1946, issue of *American Foundryman*, by A. C. Den Breejen, sand technician, Hydro-Blast Corporation, Chicago, Ill., reveals that Japanese heavy industry on a full wartime basis never compared favorably with that of our own foundries and factories. The extent to which the Japanese foundry production fell short of typical American foundry production in quality, uniformity, finish, and efficiency of production methods has been clarified by castings, molding tools, and sand specimens sent from Japan by Charles H. Krause, formerly sand technician, Hydro-Blast Corporation, with such information about operating methods as he was able to obtain on inspecting the Imperial Navy Yard at Yokosuka.

The foundry building at this Imperial Navy Yard at Yokosuka measured approximately 75 × 200 ft, had corrugated sheet-metal walls, peaked roof, and skylight, and was equipped with electric lighting and running water. A foundry building of such construction would be suitable only for milder climate sections of the United States.

Shop equipment at this plant consisted of a cupola, several nonferrous furnaces, a 5-ton electric overhead crane, several hand-powered jib cranes, wooden flasks for heavy castings, snap flasks for smaller castings, and miscellaneous tools such as riddles and shovels similar to those used in American foundries.

No evidence of mechanized equipment used for sand preparation and handling was found. There were no sand mullers, belt conveyers, sand cutters, or sand slingers which are standard equipment in American foundries. This indicates that all sand-preparation operations were performed manually—a tedious and unpleasant task.

Sand used in this foundry appeared to be crushed gravel, somewhat similar in character to that used in this country as "opener sand" on heavy steel castings. It was difficult for the observer to determine what methods were used for sand preparation. Apparently, all operations were manual. Methods used may have been similar to those used in small jobbing shops in the United States. There was no evidence of any attempt to reclaim sand as has been practiced in this country for the past several years.

The hand tools used by molders were crude and awkward. Nearly all were handmade, fashioned from cold-rolled stock or cast in iron or brass. Sufficient evidence was found to indicate that as the war years passed the Japanese industry felt increasing pressure due to shortages and was compelled to improvise and make liberal use of substitute materials. Good examples of this are the molder's brushes made of goat hair set in handles made from ordinary packing-box boards or bamboo wood. These molding tools, by comparison with comparable tools used in American foundries, appeared antiquated and crude. They are approximately the same in size but heavier in weight than American tools used in similar applications.

Examination of one aluminum and two brass castings made shows lack of good surface finish due to the use of sands which allowed metal penetration. Shifts resulting from poorly made or abused patterns or inferior flask equipment were a common occurrence. Castings of this quality would never pass even careless inspection in any American foundry.

Automatic Rainmaker

AN ingenious device which provides water by overhead sprays for cultivation purposes when the soil registers that it requires more moisture for sustenance of planted crops has been invented and put into practical use by Australian engineer Roy W. Newton, according to the July, 1946, issue of *Australia*, a monthly bulletin.

On his orchard and poultry farm at Mitcham, an outer suburb of Melbourne (Victoria), Mr. Newton has one third of an acre served by four of his automatic sprays. One spray is always in action at a time. They alternate every 35 seconds. Every two minutes the cycle is repeated until the spray waterfall is sufficient. The area is continuously covered with green clover. The one third of an acre yields 2000 lb of cut green feed each week, more than sufficient to feed 5000 fowls.

The automatic spraying device depends on the opening and closing of water taps without any manual control. By utilizing two of the physical properties of water, weight and pressure, Mr. Newton has been able to devise a series of water taps which open and close the water flow in sections for any predetermined time. The system becomes fully automatic when coupled up with the new tap, which is the result of American research work, and it is now an instrument which measures soil and moisture content. This American principle makes exact scientific decisions as to when the spray system goes into operation and cuts out.

There is no wastage or soil-flooding and water can be applied to plant growth according to exact scientific findings as to the amount of water plant life requires to sustain optimum growth. Overhead irrigation comes into operation when the crop requires water either through evaporation on a hot day or the drawing off of moisture from the soil as the crop grows. The system goes much further; it commences to operate when the temperature reaches frost degrees. It has been known for several years that the effect of frost can be defeated by water spraying. The construction principles of the spraying system make it possible to keep a continuous fine spray of water over

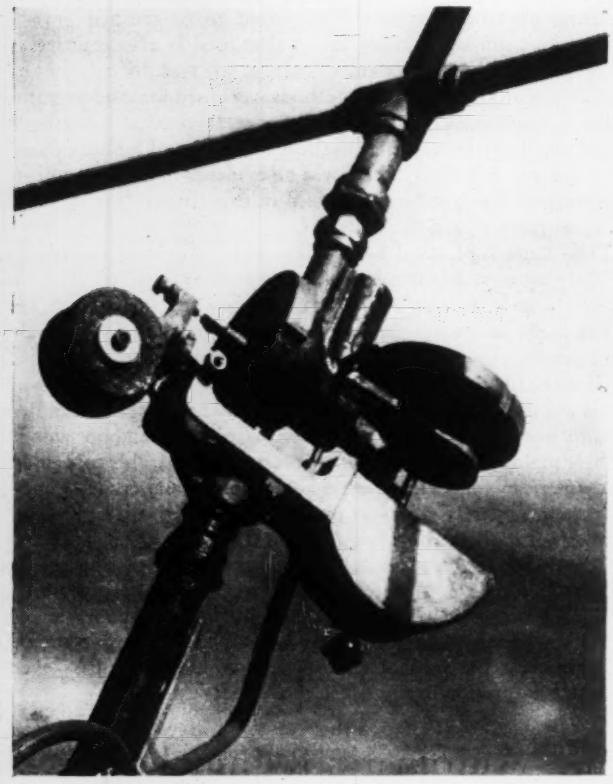

FIG. 5 TAP MECHANISM OF WATER-SPRINKLING DEVICE
(Machine does not require supervision as water is automatically turned off when soil has received sufficient moisture.)

vegetable life during nights of frost. It might be of particular value to crops like tobacco, citrus fruits, and others sensitive to frost conditions.

The practical application of the invention is already considered by experts to possess great possibilities. The normal irrigation of fruit-growing areas by water channels is costly, and water conservation in Australia is greatly exercising the minds of Australia's scientists and water-conservation engineers. The invention provides water not only when it is needed but it eliminates waste in overwatering.

Aviation

A FEW of the things that Lieut. General James H. Doolittle, vice-president, Shell Union Oil Company, sees ahead in the field of aviation are related in an article in the September, 1946, issue of *The Clarkson Letter*. They are:

Of the several advantages of travel by air, speed is probably the greatest. Substantial increases in the speed of conventional aircraft through improved aerodynamic design and jet propulsion may be anticipated in the near future. They will approach speeds of 1000 mph. These experimental planes may be expected to teach the lessons necessary to permit efficient military and commercial operations at these and higher speeds.

Pilotless, wingless, gyrostabilized rocket-propelled air weapons have already achieved speeds of around 2500 mph and we may anticipate that air weapons of the future will also be radio-controlled and radar-directed. They will be capable of traveling great distances, at supersonic speeds, in the stratosphere, and will probably have an atomic war head and may even employ energy as a propulsive force. This is tomorrow's military problem.

The employment of such air carriers for commercial air transport is the day after tomorrow's problem.

Today's primary problem is increasing the safety and reliability of conventional aircraft. Reliability, in general, means ability to adhere to schedule.

The three principal problems to be solved are: the mechanical, the airfield, and the weather problems. The mechanical problems associated with flight are gradually being solved and a higher degree of mechanical perfection achieved.

More, bigger, and better airfields poses a point of paramount importance to air development but it is personal or political rather than technological.

The greatest deterrent to the safety and reliability of aviation is our present inability to predict and combat weather.

In air operations in both the European and the Pacific theaters of war, weather was the number-one enemy. Enemy fighters were number two, and enemy flak number three. During Von Runsted's break-through in late December, 1944, when the Eighth Air Force flew in spite of weather in order to cooperate with the harassed ground forces, their losses due to weather (crashes on take-off and landing and collisions in the air) were greater than the losses due to enemy action.

Air mass analysis, global weather forecasting, long-range forecasting, and synoptic climatology have all improved our ability to forecast weather, but much more work has to be done before meteorology has made its proper contribution to air safety. More information and more accurate information is required.

Ice formation on the wings and other parts of the airplane has long constituted a serious hazard. Further development of pneumatic, thermal, and chemical de-icers is required.

Fog remains the greatest enemy. Radio, radar-locating devices, and instrument landing equipment are now available but must be simplified, standardized, and installed.

Coal-Burning Gas-Turbine Locomotive

SOME idea of how the first American gas-turbine locomotives will be built was revealed by the Allis-Chalmers Manufacturing Company recently, when Bituminous Coal Research, Inc., accepted an Allis-Chalmers contract for a gas-turbine power unit designed to run on pulverized coal. B.C.R.'s Locomotive Development Committee, representing railroad and coal companies co-operating in a project to build a better coal-burning locomotive, expects to have the new-type locomotive on rails within two years.

High efficiency, low operating cost, and easy maintenance are several specific advantages claimed for the locomotive's power-generating equipment. The 3750-hp gas turbine is to be a packaged unit, with a single base common to all parts—the gas turbine, its axial compressor, a generator driven through gears, and the regenerator. This powerful, lightweight, gas-turbine power plant will be installed in a single cab no larger than used for present-day standard locomotives.

Using electric drive, the locomotive will have a generator operating at high rotative speed, so that a relatively small diameter will allow for auxiliaries or other equipment to be mounted above the generator. The gas turbine's control system will be at least as simple to operate as other locomotive types.

It is reported that this railroad gas turbine will be the most efficient, single-shaft, gas-turbine plant in this country. The

design includes an axial-flow compressor to compress air which will then be heated to 1300 F before entering the gas turbine. This will result in a shaft efficiency of approximately 24 per cent.

When eventually produced in quantities, gas-turbine locomotives can be expected to compare favorably in cost with other types of locomotive power, according to engineers. An outstanding fuel-cost advantage comes from the use of pulverized coal, at the same time eliminating smoke and cinders.

The new locomotive will need no water. It will take on the same-size coal as carried by the steam locomotive, but the coal will be prepared for burning with special equipment now being developed by John I. Yellott, member A.S.M.E., director of research for the Locomotive Development Committee. This new coal-handling system, which will be applied to gas turbines for the first time here, will make use of a "coal atomizer" for pulverizing the fuel, as well as a unique separator for removing most of the fly ash from the heated air stream.

A brief description of a typical coal-burning gas turbine adapted from a paper presented by Mr. Yellott before a meeting of the Fuels Division of the Metropolitan Section, A.S.M.E., New York, N. Y., on Feb. 5, 1946, appears in the May, 1946, issue of MECHANICAL ENGINEERING, pages 465-466.

High-Speed Camera

A NEW, ultra-high-speed camera capable of taking photographs at the rate of 200,000 frames per second was announced by the National Advisory Committee for Aeronautics. Developed for the purpose of visually "slowing down" the rapid combustion in an aircraft-engine cylinder for leisurely study, the new camera will take ten photographs in the space of fifty millionths of a second. This is more than sufficient to stop the motion of an object traveling at 4760 mph. Inventor of the camera is Cearcy D. Miller, who is an engineer in the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics, Cleveland, Ohio.

The camera is of the so-called optical compensator type, which means essentially that the photographs are taken with continuous illumination of the object, rather than with intermittent lighting by electric spark or other means. The light source is a high-intensity gas-filled flash tube. Using stationary film, the camera produces 204 stationary images in successive positions during the one-thousandth of a second interval of one flash. It is probably the fastest camera known using the optical compensator principle, and probably also the fastest that is capable of taking a series of photographs long enough to be regarded as a sustained motion picture. When projected on a screen at the rate of 16 frames per second, the apparent duration of events on the screen is 12,500 times as long as the actual duration as photographed.

A previous camera, also invented by Mr. Miller, which took pictures at the rate of 40,000 per second, uncovered much new information on the subject of engine knock. But it was found that the occurrence of knock frequently took place in an interval of only fifty millionths of a second, requiring much higher photographic speed. The new camera was developed for this specific study. It will furnish series of pictures with only five millionths of a second between frames. Where the old camera took two frames, the new one takes ten in the same interval. This makes it possible to study in detail the development and propagation of detonating combustion. A more rapid advance in the solution of this still unsolved problem is expected through use of this new research tool.

Future applications of the high-speed camera are wide. It can be used in all kinds of high-speed airflow investigations such as supercharger and compressor studies where blade speed may be as high as 20,000 rpm. In such cases kerosene vapor is used to visualize the flow. It can also be applied to all kinds of high-speed machinery where analysis of complicated motion is required. Such uses include study of valve motion, gears, looms, and many other fast industrial machines.

Speed Selector

DEVELOPMENT of planetary motion in which two standard-cross-section V-belts and four variable-pitch pulleys provide infinite ratio, stepless speed from full down through zero and into full reverse at constant torque of two-horsepower capacity is jointly announced by Speed Selector, Inc., Cleveland, and The B. F. Goodrich Company, Akron, Ohio.

A slight change in the variable-pitch pulleys of the speed selector brings a large change in output speed through the multiplying action of the planetary mounted on the motor or driven shaft of the machine on which it is used, eliminating need for special mounting brackets or extra guards.

In operation the variable V-planetary speed-selector system compares the ratios of two V-belt drives and applies the difference in speed to output shafts. With the ratios equal, the difference in speed and output-shaft speed is zero. If the ratio of one drive is greater than the other the output shaft rotates forward at a speed proportionate to the difference in ratios. If the ratio is less, the output shaft operates in reverse in the same proportionate ratios. Speeds from 400 rpm to zero, forward and reverse, can be obtained.

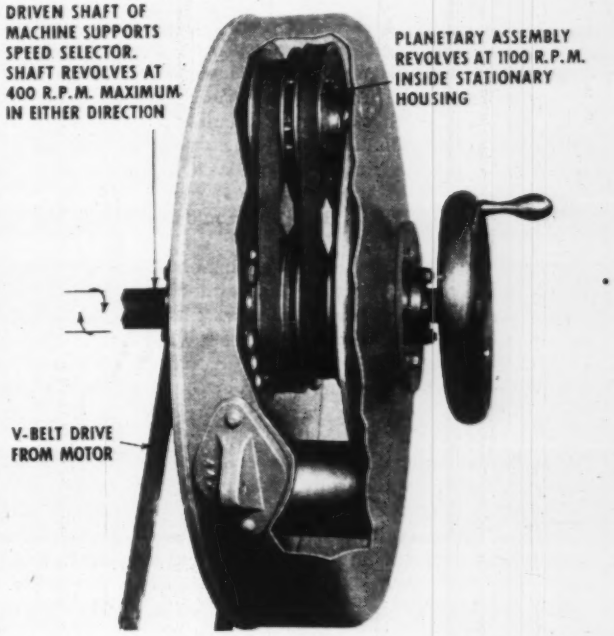
DRIVEN SHAFT OF MACHINE SUPPORTS SPEED SELECTOR. SHAFT REVOLVES AT 400 R.P.M. MAXIMUM IN EITHER DIRECTION
PLANETARY ASSEMBLY REVOLVES AT 1100 R.P.M. INSIDE STATIONARY HOUSING
V-BELT DRIVE FROM MOTOR

FIG. 6 SPEED SELECTOR

All changes are made by a hand-control wheel which alters the pitch diameter of the center pulleys so that as one is increased the other is decreased and the change imparted to the outer pulleys by the wedging action of the V-belts. It is mounted on the input shaft of the driven machine by a tapered collet. The wheel thus controls diameter of all four pulleys without use of springs or complex linkages.

Surface Coatings

DURING recent years it has become more and more evident that finished metal parts require some form of surface coating as an aid to lubrication and to prevent scuffing and rapid wear. Of recent years there has also been a continuous effort to improve the surface finish of metal parts that are required to operate in contact with other parts under heavy loads. The general belief has been that surface finishes could not be too perfect; up to a certain point this is true, but the statement is subject to qualification.

The need for, and the usefulness of, surface coating on metal parts to improve wear conditions has been investigated thoroughly by the Wilcox-Rich Division of the Eaton Manufacturing Company, Detroit, Mich., and the results of this study are discussed in an article appearing in the July, 1946, issue of *Machinery*.

While metal parts have been finished to a higher and higher degree, the necessity for running-in the mating parts has always been recognized. It has become obvious that two parts which have run together for a certain period of time have some quality that cannot be produced by present methods of finishing, and it has been deemed necessary to run parts together slowly with light loads and to lubricate them copiously during the running-in periods.

One of the most outstanding developments of recent years in the finishing of metal parts is the surface-finishing process originated by the Chrysler Corporation. This method is capable of producing finishes to almost any specified profilometer reading. The fact remains, however, that perfection of surfaces in itself is not a guarantee against seizure. In fact, such perfection invites this difficulty.

C. E. Johansson, of precision gage-block fame, proved, as early as 1917, that two perfectly finished surfaces would adhere to each other as if welded together. He said that the molecules in the separate pieces, if they were wrung together, would be as close to one another as the molecules in each individual piece. Mr. Johansson, in attempting to prove this theory, made two pieces of like material with such perfect surfaces that when about $1/2$ in. of one surface was wrung together with another surface of like size, the point would support a weight of 220 lb.

Further, O. E. Green, of the Johansson Gage Division of Ford Motor Company, reports an instance where two gage blocks that had been wrung together were left in this condition for some weeks. At the end of this time it was found so difficult to separate them that, when forced apart, particles of one block adhered to the other so tenaciously that the gage surfaces were ruined. This shows that perfection in surfaces can cause seizure.

A number of manufacturers have also found that parts that had run together successfully, when subjected to no other change except improvement in the surface finish, would seize in the initial running together of the parts. This has led to finish specifications of minimum as well as maximum profilometer readings. It has also led to a practice of producing a certain type of microscopic roughness on a highly finished surface to prevent initial seizing. In other words, it has been found that a certain type of roughness is advantageous in preventing seizing in the initial running.

What are known as excessive-pressure lubricants were found to be useful for the running-in period because they contained sulphur or some other ingredient that contaminates the surfaces and prevents welding. Surface coatings on the parts running together have also been found of value for the same purpose.

As early as 1935 the Wilcox-Rich Division started to carry out experiments with surface coatings. In general, the desirable properties of a satisfactory coating seem to be: (1) It must respond to varying degrees of pressure; (2) it should have mild abrasive action to aid the running-in of the two parts; (3) it should slightly contaminate the metal surface to prevent welding; (4) it should absorb oil and thereby improve lubrication; and (5) it should etch the surface, leaving a somewhat porous surface to provide an escape for worn-out particles and to form minute reservoirs for oil.

The coatings suitable for this purpose are applied either by electrical or chemical processes. In the chemical group one of the first coating materials experimented with was potassium sulphide, commonly known as liver of sulphur. This coating proved to be satisfactory as a means of contaminating the surface against welding, but it lacked the other necessary properties of a suitable coating material. It also had the disadvantage of being quite soft and wearing off in a short time.

A more satisfactory, easily applied material is ferrous oxide, which may be produced on cast-iron parts by heating them to approximately 1050 F, and then introducing steam into the furnace. In many instances ferrous oxide applied to the surface of cam followers has represented the difference between success and failure. It has also been used with good results on piston-rings and other cast-iron parts.

One of the most universally applicable and at the same time inexpensive coatings is manganese iron phosphate. The coating is applied in a bath of phosphoric acid containing manganese, at a temperature of about 180 F. This treatment produces an etched surface and deposits a coating of manganese and iron phosphate. Exactly what takes place in the coating action has not yet been fully explained, but it is known that a relatively soft surface having a thickness of from 0.0002 to 0.0003 in. serves the purpose. The mild abrasive properties of the manganese-iron-phosphate coating also assist in the running-in of the parts. By preventing metal-to-metal contact, this coating eliminates any tendency toward welding. The etching action of the phosphoric acid produces a porous surface under the coating, which provides an escape for worn particles and furnishes minute oil reservoirs that remain even when all traces of the coating have disappeared.

Manganese iron phosphate is apparently applicable to almost any part made from ferrous metals.

Chemical Nickel Plating

A PROCESS has been developed for the production of adherent nickel deposits, of good quality, on steel without the use of an electric current, according to an article in *The Iron Age*, Aug. 8, 1946, by Abner Brenner and Grace E. Riddell, National Bureau of Standards, Washington, D. C. Deposition of nickel is brought about by chemical reduction of a nickel salt with hypophosphites in a hot ammoniacal solution. The reaction is catalytic and, under the prescribed conditions of concentration and pH, no reduction occurs in the solution unless certain metals such as steel or nickel are introduced into the bath. The reduction then occurs only at the surface of the immersed metal with the production of a coating of nickel of 96 to 97 per cent purity.

An adherent compact nickel coating can be deposited on certain metal surfaces immersed in the bath, without any appreciable precipitation of nickel occurring throughout the bulk of the solution or on the walls of the glass vessel, by employing dilute solutions of hypophosphite, about 10 g per liter. Under these conditions the deposition of nickel occurs on the surface of iron, nickel, gold, cobalt, palladium, and aluminum, but not on platinum, copper, zinc, or lead.

The composition of the baths may vary within wide limits. Some typical formulas are shown in Table 1.

TABLE 1 TYPICAL BATH FORMULAS

Bath	1	2	3
Nickel chloride, $NiCl_2 \cdot 6H_2O$[a]	30	30	30
Sodium hypophosphite, NaH_2PO_2[a]	10	10	10
Ammonium chloride, NH_4Cl[a]	50	100	...
Sodium citrate, $Na_3C_6H_5O_7 \cdot 5\frac{1}{2}H_2O$	100	...	100
Rate of deposition, mm per hr	0.006	0.012	0.005
in. per hr	0.00025	0.0005	0.0002
Appearance of deposit	semi-bright	dull	bright
Alkali for neutralizing bath	NH_4OH	NH_4OH	NaOH
pH	8 to 9	8 to 9	8 to 9

[a] 9 rows per liter.

The baths are operated at or above 194 F. In the absence of those metals which catalyze nickel deposition, the baths are fairly stable. A bath containing hypophosphite has been kept at 194 F for 5 hr without deteriorating very much. At room temperature a bath is stable for several days.

Bath No. 1, Table 1, is the preferred composition. Bath No. 2, which does not contain any nitrate, plates more rapidly than bath No. 1, but the deposits are dull and more likely to be rough, and the bath does not remain as clear during operation. Bath No. 3, with no ammonium salts, gives the brightest deposits, but had the disadvantage that after the deposits had reached a thickness of about 0.0002 in. they ceased to become thicker even after several hours.

Gallium Thermometer

A GALLIUM thermometer, used in Germany for direct temperature readings up to 1200 C (2192 F), is described in a 12-page report (PB-25550) now on sale by the Office of Technical Services, Department of Commerce, Washington, D. C. This type of thermometer is often used in Germany for measuring temperatures which could otherwise be measured only by thermocouples, disappearing filament pyrometers, or other indirect means.

Gallium thermometers were found in use by a British Intelligence Objectives Subcommittee in a German aluminum-reduction plant, where they were used for routine measurements in the furnace bath. A similar thermometer was seen in use in a coke-calcining retort.

The thermometer is calibrated for the temperature range of 388–1210 C. The scale is a 26-cm opal glass strip. Checking with a thermocouple revealed an error ranging from minus 23.5 C at 490 C to plus 5 C at 1000 C. However, the thermometer is intended chiefly for use within the range from 950 to 1000 C and allowance could easily be made for the uniform error in this range, according to the report.

The thermometer consists of a quartz capillary inside a quartz envelope. The capillary contains pure gallium with a slight trace of iron.

Manufacture of the thermometer, according to the investigator, evidently required craftmanship of a high order. The bottom of the thin capillary rod inside the 60-cm envelope tube was broadened out and fused with the envelope to form a bulb. After the proper amount of gallium was put into the bulb, evidently under vacuum, the remaining space was filled with hydrogen at about half an atmosphere pressure, and the capillary was sealed.

The lower half of the envelope, which would be immersed in the furnace bath, is protected by a steel sheath. The top of the envelope is finished with a nickel-plated cap.

Resilient Neoprene Pellets

NEOPRENE is now being formulated with abrasive particles into tiny resilient pellets that act as an abrasive to smooth the rough edges of metal stampings, castings, and precision-machined parts, according to an article in *Rubber Age*, April, 1946. The pellets are used in tumbling barrels for deburring parts made of brass, steel, or the light metals. A well-known California manufacturer selected neoprene after testing more than 100 combinations, according to a report from E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.

Composed of aluminum oxide bonded with neoprene, the pellets may be used in virtually any tumbling barrel. However, a special barrel lined with neoprene is recommended inasmuch as the neoprene lining resists abrasion and prevents damage to delicate parts in the tumbling operation. The synthetic-rubber composition in the pellets serves both as a cushioning agent and as a matrix for the abrasive. The cushioning effect separates parts being finished, important when deburring items which have easily damaged threads, serrations, or soft-metal parts.

Neoprene also supplies a flexible backing for each particle of aluminum oxide, it was reported, insuring a constant even honing pressure as the abrasive removes burrs and sharp edges. The soft neoprene binder permits penetration into threads and serrations, bringing the abrasive in contact with all surfaces. Examination of an actual operation shows that some of the neoprene pellets wear to small pieces which reach into deep recesses and small areas and remain useful until completely worn down.

Lead-Measuring Instrument

A NEW instrument for checking the lead of helical gears and other surfaces has recently been announced by the Fellows Gear Shaper Company, Springfield, Vt.

This instrument operates on a basic principle and incorporates an arrangement whereby the lead of a helix is checked by the continuous motion of a measuring pointer, in conjunction with the desired rotation of the work. If the work being checked is of the correct lead, then the dial indicator remains stationary. If there is an error in lead, the indicator needle indicates in 0.0001 in. the displacement of the helix in the face width being measured.

The principle comprises two tangent bars and pins, both operating slides. One of these slides effects the traverse movement of the member carrying the measuring pointer, and the other the rotation of the work. The contact positions of the pins on the tangent bars are set by means of size blocks and micrometers, and dial indicators are provided so that the setting pressure can at all times be accurately maintained. Errors in gears can be checked by using the dial indicator carried on the measuring slide, or a chart can be made for permanent record.

The contact points of the pins on the tangent bars are independently adjustable, so that it is possible to have traverse of the measuring pointer without rotation of the work, and rotation of the work without traverse of the measuring pointer. This greatly increases the range of application of this instrument. In addition to checking the lead of helical gears, this instrument can also be used for checking taper and crowning of spur and helical gear teeth.

The instrument is so designed that it is easy to set up and operate, and its functioning can be accurately checked. It has a capacity for gears up to 12 in. in pitch diameter and a measuring slide movement of approximately 10 in.

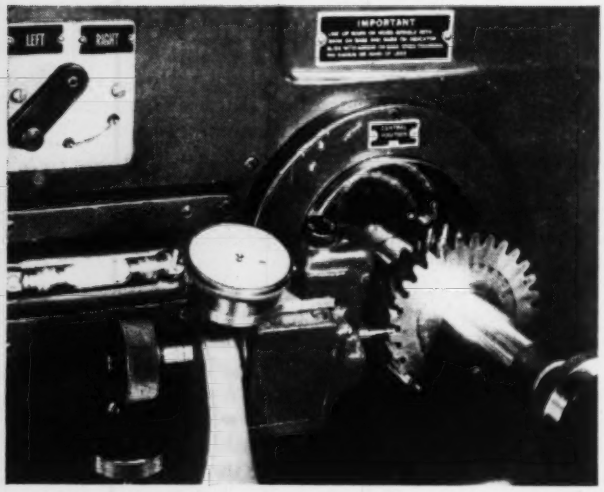

FIG. 7 CLOSE-UP OF LEAD-MEASURING INSTRUMENT CHECKING A RIGHT-HAND HELICAL GEAR.

An integral part of this instrument is an electrical recorder which automatically produces a record of the displacement of the tooth face on a paper chart. It is possible to analyze a chart and to accurately determine the amount of displacement of the tooth face in the face width of the gear measured.

Stamping Developments

ACCORDING to an article in *Western Machinery and Steel World*, August, 1946, recent improvements in the design of mechanical presses, in press controls, in tools, and in methods of handling raw materials have made possible increased production rates, lower costs, greater accuracy, less down-time, higher efficiency, increased flexibility, and greater protection to workers. A survey of leading manufacturers of presses recently completed by the Pressed Metal Institute reveals not only many improvements but also the importance of these advances in the production of stampings.

Improvements in press design include reduction of deflection, higher speeds, great precision, and faster-acting controls. They enable faster tool setting, insure longer life of clutch, brakes, pumps, and the like, and make use of "built-up" type frames. Greater effective bed area and easier repairs also result.

Some high-speed mechanical presses of 50-ton capacity are now available for operating at speeds of 800 to 1000 strokes per minute. They may be equipped with feed rolls utilizing coil stock to permit continuous operation. The controlling factors in high-speed press work are the nature of the job and the metal used. For presses operating at high speeds solenoid valves controlling start and stop operations, operated by finger-tip control, are being successfully employed. High-speed presses are of major importance for blanking, piercing, and shallow draw operations. By using multiple dies, a production of 10,000 pieces per minute has been obtained.

There is a pronounced interest in developments which tend to produce higher efficiency of press operations at lower costs. These include greatly expanded use of compound die sets, progressive dies, coiled strip-stock automatic presses, dial feeds, disk feeds, transfer feeds, push feeds, and short run or "flexible" dies.

The use of progressive dies for the production of small and medium-size stamping is becoming more and more important. Such dies perform a series of operations with automatic feeding arrangements which transfer the piece from one die to the next in time with the press motion. With each stroke of the press a completed part is produced. This arrangement eliminates the necessity of a series of presses with an operator at each press and handling of the pieces from press to press. As many as 13 stations have been installed on one press.

The use of coiled strip stock is increasing. These coils are used on presses which are equipped with coil cradles, levelers, feed rolls, and scrap cutters. This auxiliary equipment operates automatically in time with the press. Savings due to the use of coiled strip in conjunction with progressive dies have in many cases been very large.

Dial feed is ideal for getting work in and out of the die where otherwise a long idle stroke would be required to give necessary clearance. It is also ideal where loading and unloading takes considerable time, as it permits loading and unloading simultaneously with the press operation. Dial feed is indicated where considerable ejecting pressure is required, since this ejecting pressure may be applied at a station outside the press.

Dial feeds are available with auxiliary dial feeds on the slide of the press, enabling a series of punches to perform successive operation on any one piece of work in the press. All dial feeds, including dial feeds on the slide, are being operated through automatic electric control. This control makes it possible to select the number of pressings, to skip stations, and to provide safeguards against having no work in the press or having a double thickness of work in the press. Dial feeds are not limited to a particular type of press. They are being used on 5- and 10-ton gap-type presses and on 3000-ton open-rod and housing-type presses.

Transfer feeds are ideal for push-through work as they keep the operator's hands out of the danger zone. Transfer feeds have been developed for special, irregular-shaped objects and can be arranged so that the feed does not operate unless it is properly loaded.

Push feeds are being used for a wide variety of coining work. They should be fast operating since the coining work involves a short stroke with a fast pressing cycle. Obviously, slow moving feeds handicap production.

Die slide systems of multiple loading are desirable where there is an assembly problem or a loading problem. Examples are: where a considerable number of component parts must be assembled loosely in a stack or pile, or in a fixture, or where considerable preparation is required. The rubber-pad press as used in the aircraft industry for the short runs on simple dies is an ideal illustration of the use of a die slide. A number of dies can be placed on one die slide with the work placed on top of the dies; and where as many as 26 or 30 dies are used on one slide it might take 5 minutes to load, whereas the die slide on the opposite side of the press may have one large die requiring only a short time for loading. On the properly built die-slide press, flexibility of operation permits any die slide to go in when prepared, provided the press is empty at the time. In connection with the illustration mentioned, the large single-piece die slide might move into the press two or three times while the die slide carrying several small dies is being loaded. Die slides should also be used where the assembly of a series of laminations require considerable time. In general, the die slide means that one press will do the work of several presses, since the use-factor of the press itself is maintained as a high point, whereas presses without die slides may have a use-factor of only 10 or 15 per cent. The number of die slides may be 2, 3, 4, or even 6 on specially constructed presses such as were used in the larger aircraft factories.

Although advances during the past few years in the design of mechanical presses have been marked, press engineers predict that the next few years will see many new developments.

5000 Kw Standard Power Plant

A 5000 kw standard power plant for peacetime use under widely varying climatic conditions has been engineered by Ebasco Services, Inc., New York, N. Y., for the Westinghouse International Company.

Considered a "standard," the plant, however, was designed with a high degree of flexibility to allow a surprising amount of tailoring for operation at maximum efficiency in a specific location or under unusual conditions. It is also possible to incorporate certain modifications or special features desired by the user.

The plant utilizes only one boiler to supply the steam requirements of one turbine. For certain installations, however, this is neither possible nor desirable. Additional boilers to serve either as stand-bys or to furnish process-steam requirements are often necessary. To meet such conditions, the plant can be adapted to include additional boilers, the capacities of which would be determined after an engineering study of the user's requirements. The plant is served by a generously sized steam generator having a continuous rating of 75,000 lb per hr and operating at a pressure of 450 psi and a steam temperature of 760 F (460 psi, 750 F at the turbine).

A contribution to over-all efficiency was obtained by utilizing a spreader-type coal stoker co-ordinated with a continuous-discharge traveling grate having automatic speed control. An economizer for raising the final temperature of the feedwater to 276 F before it enters the boiler is included as standard equipment. To obtain similar efficiency in the oil-fired unit, an air preheater replaces the economizer.

The steam boiler itself is of modern bent-tube design employing water-cooled walls and designed to operate at an efficiency of 83 per cent even when fired with as poor a fuel as lignite. A boiler efficiency of 85 per cent is obtainable with an oil-burning installation.

In a representative coal-burning installation, coal is delivered to the boiler by means of a motor-driven fuel-handling system. This fuel-handling system can supply in eight hours the full-load requirements of the power unit for a twenty-four hour period. During operation the boiler ashes are continuously discharged into a concrete ash hopper from whence they are periodically transferred to an ash car.

Important items in the feedwater system are duplicate boiler feed pumps, one motor-driven and one turbine-driven, each pump capable of supplying boiler-feedwater requirements appreciably in excess of the boiler demand even when operating at maximum peak load.

Because of different water analyses encountered in various districts, particular care had to be taken in the design of the deaerator and evaporator. The evaporator, for example, is designed to produce a vapor containing not more than 5 mg per liter of total dissolved solids. In locations where the water is particularly bad, equipment for water pretreatment is included.

The condenser shell acts as the structural support for the turbine generator. This design is employed to give a compact, integrated unit exceptionally rigid, misalignment-proof, and practically vibrationless. The turbine generator operates at 3600 rpm and is capable of developing its maximum rating of 6250 kw continuously even under the handicap of a condenser cooling-water temperature that in summer might reach as high as 32 C (89.4 F).

Two bleed points are utilized for regenerative feedwater heating and a third point for heating the coils of the plant make-up water evaporator, or alternately for a third stage of regenerative heating.

Since the quality of returning condensate in the feedwater system has a direct bearing on the maintenance problem of the boiler feed pumps, a deaerating type of condenser is used to obtain the best possible oxygen-free condensate.

The electrical system for the power plant is laid out along conventional lines.

Continuity of operation is assured by standardizing on heavy-duty switch-gear specifically designed for central station use. Both the high-voltage and low-voltage electrical switchboards are of the metal-enclosed dead-front type. All station auxiliary-feeder circuits are protected by automatic air circuit breakers equipped with both instantaneous trips for short-circuit protection and thermal overload relays with time delay for overcurrent protection.

New Inside Micrometer

MEASURING bores without removing boring bars is now possible with the new tubular over-the-bar inside micrometer manufactured by the Tubular Micrometer Company, St. James, Minn. This new precision-measuring device is used to determine bore sizes over or around center obstructions. Unlike conventional inside micrometers and rods, which require removal of the boring bar and disturbing the cutter settings, use of the tubular micrometer does not entail this laborious extra work. Instead, it is merely placed around the bar in correct measuring position and the micrometer reading is taken.

The micrometer is made with hollow-box type steel frames resulting in a 50 per cent saving in weight over a solid-frame type micrometer of the same size.

All the frames have a vacuum in the center to insure minimum expansion and contraction. Hand heat will not affect the micrometer reading for it is dissipated in the vacuum and does not distort or follow the metal frame. The frames are hydrogen-brazed and are plated with copper, nickel, and heavy chrome to resist wear and perspiration.

FIG. 8 MEASURING INNER BORE OF A LARGE PITMAN

Bearing Display

REPRESENTATIVES of American and Russian industry were shown an exhibit displaying the application of Timken roller bearings in industry at a press preview held on Aug. 15, 1946, in the workrooms of Messmore-Damon, Inc., New York, N. Y., the builders.

The display, planned and constructed over a period of two years, will be part of a giant International Industrial Exposition to be held in Moscow, Russia, late this year. The project was under the direction of Walter C. Sanders, member A.S.M.E., general manager, Timken Railway Division, The Timken Roller Bearing Company, Canton, Ohio.

Its main feature is a one-quarter size working model of a Norfolk and Western 600 series locomotive, whose boiler and cab section are separate from the frame, and periodically raise and lower by means of an automatic mechanism. While the boiler and cab are in a raised position, the lead truck wheels, driver wheels, and trailer truck wheels are in operation. Housings are cut away so that the operation of the bearings may be seen.

Made at the invitation of the U.S.S.R., the exhibit will shortly be shipped to Russia.

Centrifugal Casting

A REPORT on the status of centrifugal-casting practice in Germany immediately after V-E day is presented in the July 25, 1946, issue of *The Iron Age*. The article is adapted from a report prepared by James F. MacKenzie, chief metallurgist, American Cast Iron Pipe Company, Birmingham, Ala., for the U. S. Technical Field Information Agency.

Centrifugal casting of metals was developed in Germany to a degree comparable with that in the United States and rather beyond that in Great Britain. The largest tonnage item, that of cast-iron pipe, was without significant developments, the methods and machines being those in common use for some time before the war.

The manufacture of automotive cylinder liners and barrels was on about the same plane of technical development as in the United States and Great Britain. The use of thin silica-sand lining was new and may turn out to be an important contribution. For cast-iron liners, the machines and methods are the same as developed by Hurst in England, but for steel liners the machines are nearly the same as the newest machines in the United States, i.e., those at Ford Motor Company and at the American Cast Iron Pipe Company. The chief advantages of these are the simple cylindrical shape of the mold, which eases the thermal stresses, and the removal of the mold from the machine after each cast, giving better control over the mold temperatures and allowing better dressing.

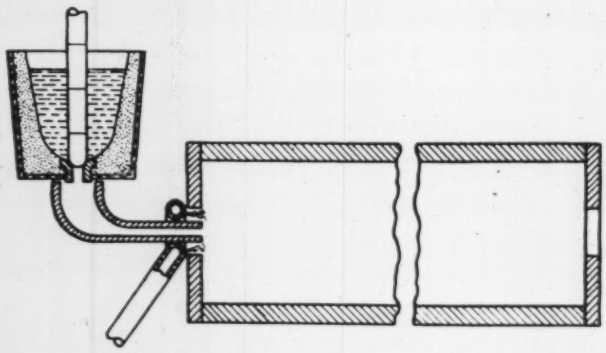

FIG. 9 MACHINE USED FOR PRODUCING LARGE BRONZE TUBING

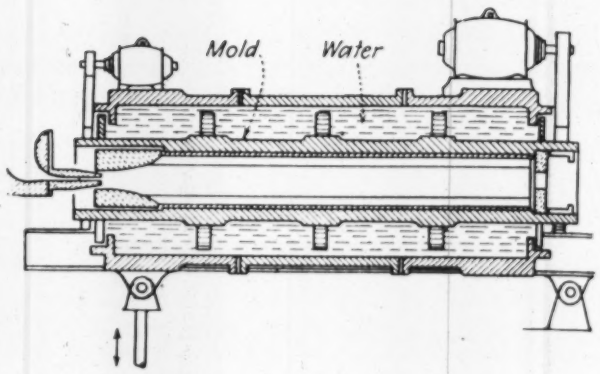

FIG. 10 CASTING MACHINE FOR STEEL TUBING AND GUN BARRELS

The casting of steel gun barrels was highly developed and the use of the thin sand mold, clean silica sand (about 30 to 70 mesh) spun in the mold just before casting, may be a real advance in casting heavy tubing. The molds used were of chrome steel, only 1 to $1^1/_2$ in. thick, and ran in water. The method of placing this lining is to put the necessary amount of sand in a trough the same length as the mold. This is mounted on a car and the sand is put in place by dumping the trough after the mold has reached full speed. For gun barrels the optimum thickness was given as 5 mm (approx. 0.2 in.) and it was stated that if the sand was too thin, e.g., 3 mm (0.18 in.), the casting would crack longitudinally, whereas if it were too thick, e.g., 7 mm (0.28 in.), it had a tendency to wash and swells were experienced. There is some penetration of the sand by the molten steel but this does not seem to result in a lifting of the sand and the sand comes off very readily in the heat-treatment that follows.

The vertical method in use does not seem to be as good as the horizontal method in the United States. A weighed amount of steel is poured into a heavy cast-iron mold spinning at about 200 rpm, care being taken that the stream does not strike the mold wall. When all metal is in, the speed is increased to 1400 rpm for the 88 mm (3.46 in.) and up to 2000 rpm for the 60 mm (2.36 in.) barrels. As a matter of fact, the vertical method of spinning gives really an ingot with the piping and segregation accentuated and highly localized so that on boring the barrel only good steel is left. The paraboloidal cavity in the 88-mm gun extends only some 3 or 4 ft down from the top as cast and a foot or so of this was removed in machining. Physical properties of the barrel, however, as reported, were as good as the horizontally cast. It seems that the breech of the long guns was not cast so thick as the U. S. guns and the Germans said the practice was to shrink another tube on these guns.

The thin sand-lined mold was also used successfully for the horizontal spinning of high-chrome-steel tubing. This operation utilized a water-cooled metal mold with the thin sand lining, using a thickness of sand of only 2 mm (0.079 in.) and the surface looked very good indeed. However, the high-chrome steel-tubing wall thickness was much less than that of the gun barrel. This steel would be difficult to oxidize in heat-treatment if it penetrated the sand like the carbon steel but it did not seem to do so. These tubes are cast up to 500 mm (approximately 19.7 in.) in $3^1/_2$-meter (10.6-ft) lengths, wall thickness of 1 to 2 in.

Vertical spinning in cement sand molds or oil sand cores is apparently on a par with similar production in the United States. The general method is to pour while the mold is sta-

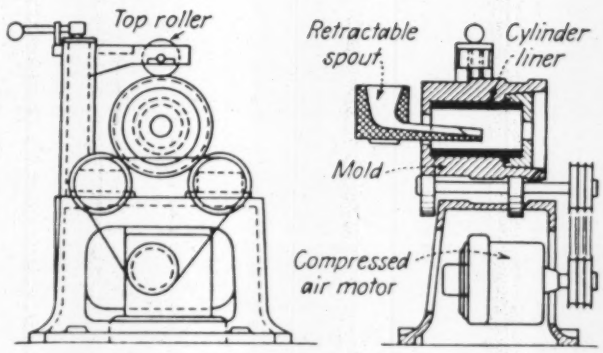

FIG. 11 CASTING MACHINE USED FOR CYLINDER LINERS

tionary and then spin at about 300 rpm. The principles of directional solidification are carefully observed. Ball races, brake drums, and gear blanks were being produced by this method in both steel and bronze.

Casting of brass and bronze is done in quite large sizes. Tubes up to $2^1/_2$ meters (8 ft) diam are spun up to 3 or 4 meters (9.8 or 13.1 ft) in length, and tubing of 1 meter OD is made up to 12 meters in length (40 ft), the limiting factor in length and thickness being the capacity of the furnace which was 22 tons. One feature of considerable interest was the use of a thin copper sheet as a lining for the cast-iron mold. This is cut exactly to size and slipped into the mold just before casting. The Germans fill the mold with burnt coke-oven gas before pouring and keep the gas on until the bronze is set. This was said to eliminate pinholes and to add greatly to the life of the mold. They also appear to be using very high speeds on their nonferrous work.

At one plant it was reported that for facing, about an ounce of graphite powder was thrown in the mold before casting. A suction system collects the graphite after the extraction of the casting, cleans it of iron by a magnet, and returns it for re-use. The plant superintendent reported that the graphite worked better after re-use than when it was new. This plant cast gray-iron automotive cylinder liners and asserted that no heat-treatment was necessary as no chill was experienced.

Sketches accompanying this article illustrate several interesting phases of German casting equipment. Fig. 9 shows the pouring device used for casting large bronze tubing. This device consists of a small ladle with a bottom orifice and a graphite stopper, the latter being used to hold the metal until the ladle is full. The size of the orifice varies with the metal weight. The ring burner at the head of the machine is used to fill the mold with inert combustion products before and during pouring.

Fig. 10 is the machine used to cast steel tubing and gun barrels. It is a heavy machine with three sets of four rollers. The flask is direct-driven through a train of gears by a motor in the side of the machine and runs totally immersed in water. Ends are sealed by flat rubber gaskets. This machine tilts to an angle of 12 to 15 deg during casting and stripping.

A battery of six machines of the type shown in Fig. 11 were used for casting motor cylinder liners. This is a simple three-roller type driven by air motors in which the cylindrical flask lifts out, as in the Ford and Acipco units in this country. This type of machine was also used for steel liners for automotive engines.

Fig. 12 (right) shows the arrangement used for casting the steel cylinder liners in the machine that is illustrated in Fig. 11.

Small Plants

IN a paper entitled "The Importance of the Small Plant in Industry," given before the International Technical Congress, Paris, France, September, 1946, A. C. Shire, chief engineer, Office of Foreign Economic Development, Department of Commerce, examines the place of the smaller manufacturing plants in the United States, points out their prevalence, and analyzes some of the causes which have made for their success.

There are few huge mass-production plants in the United States but there are tens of thousands of small plants each employing only a small number of persons. Nearly three fourths of all the manufacturing plants in the United States have less than a score of wage earners each, more than 90 per cent have less than a hundred.

Various definitions for "small" business have been set down, but for statistical purposes in the field of manufacturing the criterion is usually that used by the U. S. Census Bureau—manufacturers are a small business if they employ less than 100 people; or the one found in the Reconversion Act of 1944—a small plant . . . employing 250 wage earners or less.

Of the 184,230 manufacturing establishments in the United States in 1939 which accounted for the employment of nearly 8,000,000 wage earners, only 176 or approximately one tenth of one per cent employed more than 2500 wage earners each, and only 810 or approximately four tenths of one per cent employed more than 1000 wage earners each.

Ninety-six and eight-tenths per cent of all manufacturing establishments employed 250 or less wage earners, 91.7 per cent employed 100 or less wage earners, 85.2 per cent employed 50 or less, and 72.4 per cent 20 or less wage earners.

The big mass-production industries are found mainly in the metalworking group. An analysis of its employment figures and those of its principal subsidiary groups: iron and steel, machinery (except electrical), electrical machinery, automotive, and transportation equipment, shows of course that these groups run to more large and fewer small plants. However, even in these groups there are found very large numbers of small plants.

Both the nature and the quantity of products manufactured are the determining factors in sizing plants. Generally, consumer goods can be economically produced in small plants, while capital goods often require large plants.

Modern mass production and continuous assembly started about forty years ago in the United States with the building of freight cars. The output of this first shop was four to five wooden boxcars per day. The operation was comparatively simple and surprisingly effective. Henry Ford, member

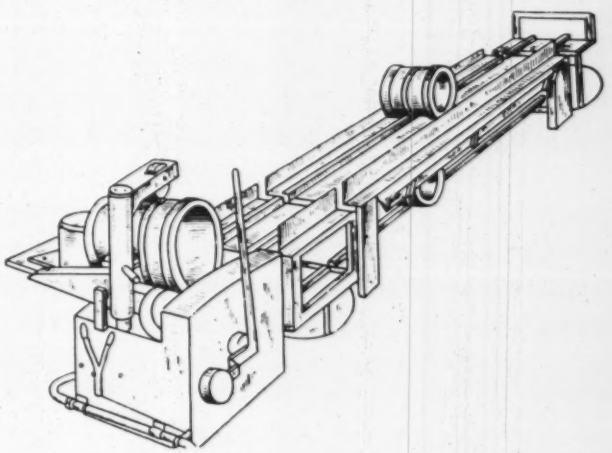

FIG. 12 ARRANGEMENT FOR CASTING STEEL CYLINDER LINERS

A.S.M.E., copied and improved upon this method. He and others developed it into an art in which, according to Ford himself, the principles of power, accuracy, economy, system, continuity, and speed are focused upon a manufacturing project.

On large and complex products, a mass-production factory must be large for assembly alone, as well as for the preparation of subassemblies and parts which are most economically made in direct connection with the assembly line. However, the general mass-production method, particularly the straight-line process, may be applied to a small part that is formed and assembled in a number of steps. If the part is small, the shop need not be large.

In a smaller shop the danger of elaborate record and control systems eating up profits is less than in a big one, since the condition and progress of the work is more easily seen. A small shop can turn out several varieties of its product, provided the quantity of each is large enough to pay either for a line process of its own or for resetting and retooling the machines, but the quantities of each must be large if the system of batches is to be avoided and the cost of storage and control kept to a minimum.

The use of special-purpose and automatic machinery in the United States is an adaptation to high wage rates in the economy as a whole as well as in the specific industry. Properly adjusted wage scales tend to create a mass market that will absorb a large volume of goods and support the high capital cost of specialized machinery.

It can never be safely assumed that large-scale operation is invariably the most efficient. The extent of its efficiency varies with the "circumstances of production." Certain types of productive operations readily lend themselves to the use of large-scale equipment; others can be more efficiently carried out with small-scale equipment.

Small industries can make effective use of standardization as a means of competition, making available to the mass-production operators a selection of parts or accessories from different sources. Manufacturers of a patented machine often prefer to use special connections, so as to retain a monopoly in the sale of parts for repair and replacement. On the other hand, machines in common use, such as automobiles, benefit from interchangeable repair parts because there is more possibility of a quick repair in a small shop with limited stock of parts.

Small manufacturing may compete with large if its product is so simple that high efficiency can be attained in a small plant, or if labor and capital will accept a low return in order to stay in business in the face of more efficient competitors. However, the possession of local and unique plant advantages can also enable small industry to remain in profitable competition.

The decentralization of small plants is important. Actual experiences in some of the war areas have shown that pinpoint bombing of strategic industrial units can be quite effective. If the target of such bombing is an industrial plant a hit may easily result in greatly diminished production if not its complete stoppage. Unanticipated disasters of other kinds can be equally effective in peacetime.

It may therefore be highly desirable to break up and decentralize considerable parts of the operation, having a number of plants in widely separated locations so that the risk of loss of any major portion is reduced to a minimum.

There are only a few industries in which large plants are necessary for achieving economical production, but for many industries the smaller plant has definite advantages. The high efficiency of close managerial control is one factor in its favor, and there are others, often equally effective. Modern technology, again contrary to popular opinion, instead of forcing the smaller plants out of business is creating new opportunities for them to function, either as independent units or as important adjuncts to the larger assembly plants.

Electrostatic Detearing

EXCESS paint or other finishing material, which accumulates at drain-off points on dip or flow-coated work, can be pulled off by an electrostatic field as a conveyer carries them through it. An article in the August 29, 1946, issue of *American Machinist*, by Dr. Emery P. Miller, Harper J. Ramsburg Company, describes the process.

In electrostatic detearing, work is suspended from an overhead conveyer in the usual fashion. After the item has been dipped it is carried over the usual gravity drainboard and allowed to air-dry until flow of surplus paint has practically ceased. Then items are carried over and spaced in relation to a metal grid electrostatically charged by a suitable power source. As in electrostatic spraying, the work is grounded and positive. The grid is negative, and usually is maintained at a potential of 85,000 volts direct current.

As unlike electrostatic charges attract and like charges repel, an attractive force is exerted upon items as they are carried across the grid. Therefore any fluid excess-coating material is attracted to the grid and so removed from the drain-off points. Removal will continue as long as the item is over the grid or as long as there is excess coating to be removed. As flow of coating on the parts has substantially ceased and the electrostatic field has removed excess material from drain-off points, parts leave the grid uniformly coated. Time required for detearing most parts ranges from 15 sec to 1 min.

The electric field used is a direct-voltage field pulsated from zero to a maximum once every sixtieth of a second. Average current through the field is approximately 0.4 ma. The power pack has an over-control characteristic which automatically decreases voltage when current tends to exceed this value. On direct short circuit of the equipment, maximum current which can be drawn is 7 ma. The power pack is connected to a standard 220-volt, single-phase, 60-cycle, a-c line capable of delivering approximately 10 amp. Normal power consumption is equivalent to a 1000-watt light bulb.

Current and voltage characteristics of the field are main

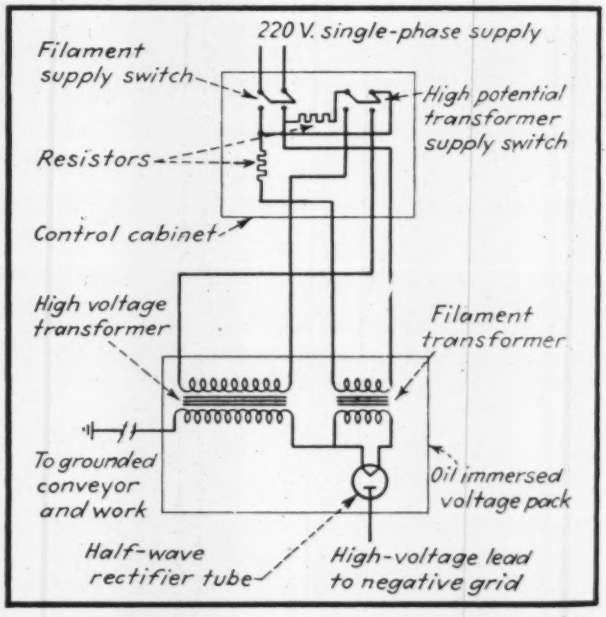

FIG. 13 POWER PACK FOR CHARGING DETEARING GRIDS INCLUDES HIGH-REACTANCE TRANSFORMER AND HOT-CATHODE HIGH-VACUUM RECTIFIED TUBE

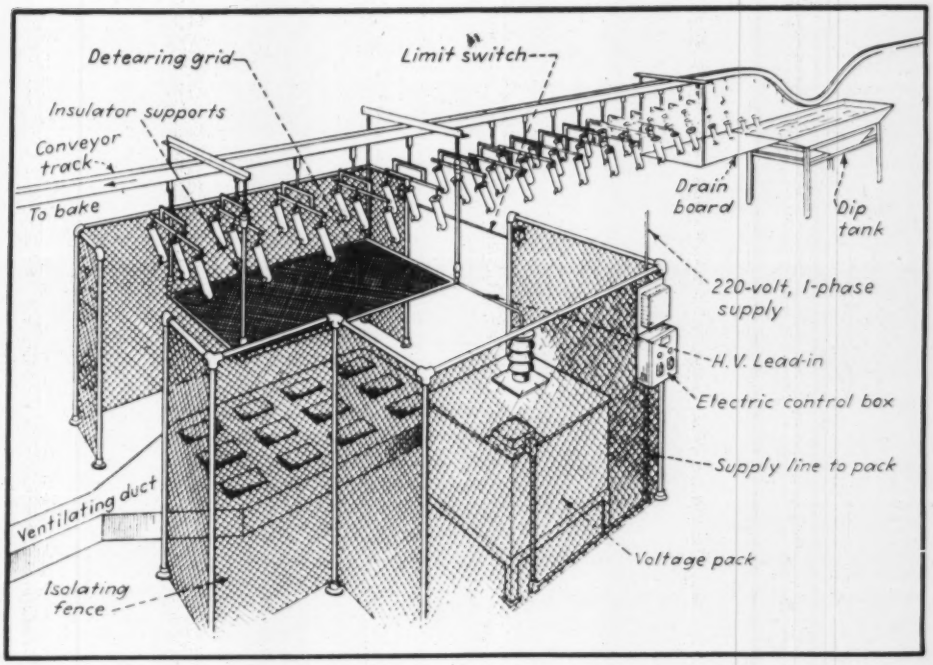

FIG. 14 TYPICAL ARRANGEMENT OF A NEGATIVE DETEARING GRID, VOLTAGE PACK, AND ELECTRICAL CONTROLS FOR ELECTROSTATIC DETEARING

tained constant regardless of the size or shape of the item passed over the grid and are held constant regardless of the type of coating material used. Detearing is independent to a wide degree of the type of coating material.

Conveyer speed is not determined by the limitations of the method, but by the production volume required. It is important, however, that dipped parts be allowed to drain properly before arriving over the grid, and that they remain over the grid long enough so no new tears will be formed afterward. These two requirements, when combined with production requirements and space available, determine conveyer speed. To decrease conveyer speed it is possible to hang the items in groups perpendicular to the conveyer. Thus for any given production, hanging two items on each hook instead of one would reduce required conveyer speed by half.

The electrode system usually consists of an expanded-metal grid supported below or to one side of the path of the work. The grid is mounted on supporting insulators. Normally, it is necessary to maintain between the grid and closest drain-off points on articles a distance of approximately 8 in. Spacing may be increased from 12 to 15 in. without materially influencing detearing. It is preferable that all points to be deteared pass over the grid at approximately the same distance. Because of this requirement it is customary to support items of different sizes on hooks of varying lengths.

It is not possible to allow the drain-off point on a part to approach closer to the grid than 8 in. because decreasing this distance increases the possibility of static sparks between grid and parts. Additional detearing action obtained by decreasing the distance between the parts and the grid does not justify this increased hazard. For this reason there usually is placed ahead of the detearing grid a limit switch which de-energizes the electrical equipment when a part is hung on the conveyer so it approaches the grid closer than the specified distance.

Objects being deteared must be grounded electrically and have an adequate electrical connection to the conveyer so they form one terminal of the field. For this reason items of nonconducting materials can be deteared satisfactorily only as long as the drain-off points are not too far away from the point of support. This distance is determined by the relative electrical conductivity of the material of which the article is made; no definite value can be stated without making tests on the items involved.

Finishing material removed from parts as they pass over the electrostatic grid is attracted to, and collects on the grid. This usually is not a disadvantage because the amount of material collected during a production operation usually is very small and does not influence the field. In the event that accumulations do prove objectionable, the electrode system is made so it is easy to change grids without objectionable shutdown time.

In normal installations, grids and coated articles are ventilated to insure that solvent vapors are not accumulated in the area. Ventilating ducts may be placed above the conveyer or below the grids as desired. As the air passes through the grids and about the articles, solvent vapors are removed and the setting of the material is aided to prevent reflow after detearing has been completed.

It is also important that drain-off points be of reasonably small radius so removal can be complete. Best results are obtained when this radius is less than $1/4$ in. When the radius is larger, field strength is reduced and attraction forces are proportionately smaller.

The process is applicable to all types of coating materials in normal use as long as these materials can be used in a dip or flow coating process to produce an otherwise desirable finish. Extremely heavy and viscous materials do not have necessary flow characteristics. Materials suspended in a water base are not deteared as effectively as are other types of finishing materials. Electrostatic detearing only removes excess coating material from drain-off points; it plays no part in aiding or speeding the flow of the coating material over flat surfaces.

In general, this method is applicable to any item whose shape is such that a satisfactory coating can be obtained over the major portion of the part by normal dip. It is therefore essential that articles do not have any sections which trap or pocket liquid and which therefore prevent free drain of the coating material to an exposed drain-off point. Items so shaped that their normal drain-off points are enclosed or shielded from action of the grids also offer some difficulty.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Future Use of Coal in Railway Motive Power

COMMENT BY F. T. HAGUE[1]

The introduction of the gas-turbine power plant into the locomotive field, as noted in the paper,[2] will bring its own problems of fuel supply. Today, the gas turbine is a liquid-fuel-burning device, but tomorrow we expect it to burn pulverized coal. Its fuel will be governed by a specification in much the same way as Diesel fuel is controlled, except that this specification may be highly restrictive with respect to the rank of the coal and the characteristics of the pulverized product.

Fig. 1 of this comment shows a scale model of a 2000-hp gas-turbine power plant which will shortly be available for test. This power plant uses bunker C oil. The arrangement of the components will be modified when burning pulverized coal.

We are approaching the problem of designing a pulverized-coal supply system and combuster from the background of experience with liquid-fuel combusters for the jet-propulsion-type gas turbines. As of 4 years ago, no one had ever built combusters small and light enough to be suitable for aviation. The first ones constructed resembled flame throwers. After 4 years of endeavor, gas-turbine combusters now have heat releases above 20,000,000 Btu per cu ft per hr. Recent improvements have made it possible to cool the combuster side walls below a temperature showing color. This is over 500 times the heat-release rate of large conventional boilers. It must be obvious that conventional combustion practices are not suitable to produce these results.

This experience is both an outline and a challenge to what can be done in utilizing pulverized coal. Considerable difference of opinion may develop as to the methods to be employed in burning coal in a gas turbine. The premises set up for cost of the prepared fuel, permissible size and weight of the preparation and combustion equipment, and the character of the combustion products with respect to ash disposal can greatly affect the plan of development.

We have the choice of starting with pulverized coal of conventional fineness and low preparation cost and attempting to meet the bogies of size, weight, and ash disposal, or of starting with pulverized coal of extreme fineness and high preparation cost. The selection of superfine fuel will greatly favor meeting the size and weight bogies and in addition, offer the possibility of simplifying the problem of ash disposal.

Our objective has been the combustion of pulverized coal in the firebox of a steam locomotive, as well as in the combuster of a gas turbine. The only generalized solution of the coal-combustion problem that promises to be acceptable to both applications, is one in which ash problems, either in liquid or solid form, will be avoided. This type of solution

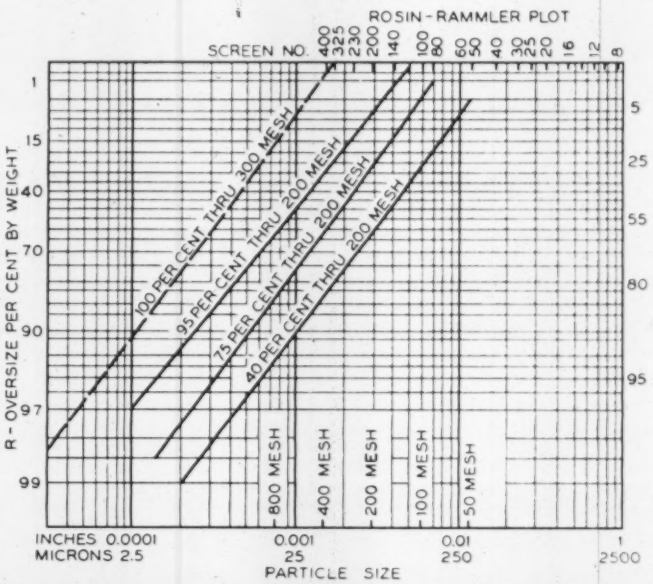
ROSIN-RAMMLER PLOT
SCREEN NO.
400 325 230 200 140 100 80 60 50 40 30 25 20 16 12 8
R - OVERSIZE PER CENT BY WEIGHT
1 15 40 70 90 97 99
5 25 55 80 95
100 PER CENT THRU 300 MESH
95 PER CENT THRU 200 MESH
75 PER CENT THRU 200 MESH
40 PER CENT THRU 200 MESH
800 MESH
400 MESH
200 MESH
100 MESH
50 MESH
INCHES 0.0001 0.001 0.01 1
MICRONS 2.5 25 250 2500
PARTICLE SIZE

FIG. 2 PARTICLE-SIZE DISTRIBUTION FOR THREE DIFFERENT DEGREES OF COAL FINENESS

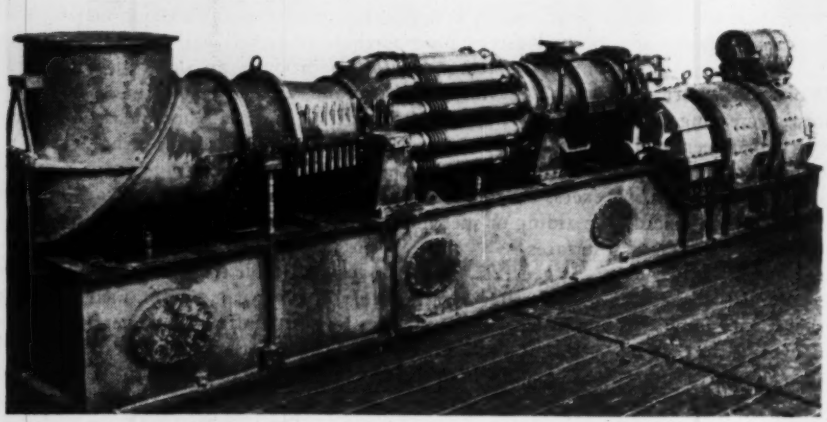

FIG. 1 2000-HP GAS-TURBINE POWER PLANT

[1] Assistant to Vice-President, Westinghouse Electric Corporation, Philadelphia, Pa. Mem. A.S.M.E.

[2] "Future Use of Coal in Railway Motive Power," by K. A. Browne, MECHANICAL ENGINEERING, vol. 68, 1946, pp. 547–549.

may possibly be found in the proper application of a suitably finely pulverized coal system. This possibility is being actively explored.

The specification of the particle-size distribution in the type of pulverized fuel required to meet this objective is naturally of paramount importance. In order to represent this distribution most clearly, we explored a suggestion from the Bureau of Mines and plotted the particle-size distribution, Fig. 2. This figure shows the particle-size distribution for three different degrees of coal fineness, as well as the distribution that we desire to meet our specification.

All types of pulverizers do not produce

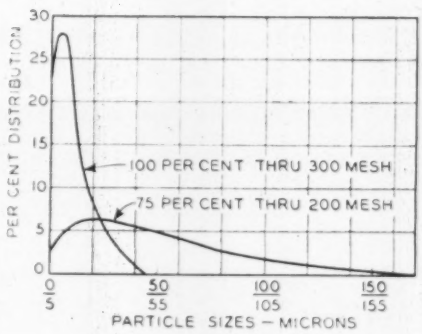

FIG. 4 PARTICLE-SIZE DISTRIBUTION OF CONVENTIONAL PULVERIZED COAL AND SPECIFICATION COAL

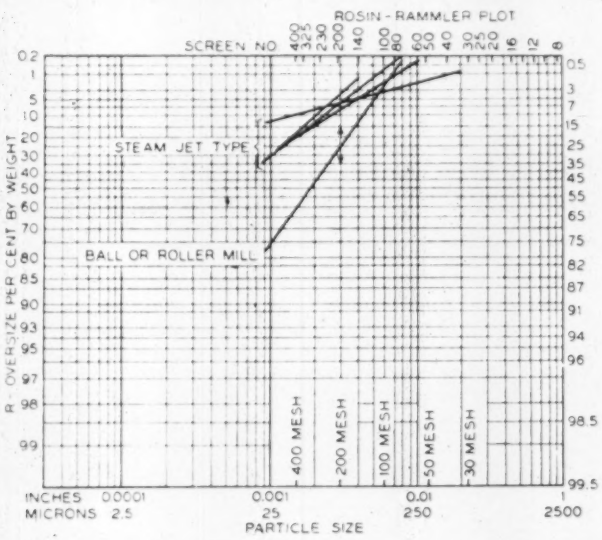

FIG. 3 TYPICAL PRODUCT OF STEAM-JET PULVERIZER COMPARED WITH BALL-MILL PRODUCT

the same percentage of fine particles. Fig. 3 shows the typical product of a steam-jet pulverizer in comparison with the conventional ball or roller mill supplying a central-station boiler.

While it is not difficult to produce a large percentage of fines in pulverized coal, it is most difficult to do this and also avoid the presence of an appreciable percentage of coarse particles. Fig. 4 shows the particle-size distribution of conventional pulverized coal and that of the coal called for in our specification.

The efficiency of the coal-pulverization process is supposed to be in the neighborhood of 3 to 5 per cent. Our hope of attaining an acceptably low cost of fine pulverization lies in improving this efficiency. It is an axiom in research that a suitable yardstick of measurement is essential to understanding and improving any process. It is hoped that this method of representing the consist of pulverized coal will permit setting up a quality criterion for the output of pulverizers. This criterion might, for example, state the per cent oversize for 10- and 50-micron particles. The straight line drawn through these two points would identify the entire consist and permit a simple calculation of specific surface of the pulverizer output. Coal interests could well support research in the pulverizing and associated classifying of coal, in the interest of wider utilization of their product.

COMMENT BY FREDERICK NETTEL[3]

Among recent proposals to utilize the gas turbine for rail traction, those employing electric-power transmission have been propagandized so effectively by builders and would-be builders of such equipment that the erroneous impression has been created that no other transmission system deserved consideration. Hydraulic transmission has been mentioned with reservations concerning its availability for large powers. (No successful hydraulic drives are known to exist for powers in excess of about 400 hp.)

The purpose of electric or hydraulic transmission on locomotives is to superimpose on the Diesel or gas turbine torque-converter characteristics which these prime movers do not possess. Such transmission must therefore be regarded as a necessary evil, to be avoided if possible.

Obviously, even a locomotive of the gas-turboelectric type utilizing bituminous or other coal with internal combustion, if that is accomplished, is hardly the complete answer to the railroads' needs, mainly because its costs will probably be the same or even higher than those of Diesel-electric types. What is needed is not just a coal-burning gas-turbine locomotive but a cheap coal-burning gas-turbine locomotive.

Many attempts have been made aiming to reduce the high cost and high weight of the electric transmission and its servicing over the whole road system.

Elastic fluid (mostly air) transmission has been tried in connection with Diesel engines driving air compressors of the reciprocating type. This system has been arranged in such manner that the compressed air was heated by the Diesel exhaust and thereafter expanded in reciprocating air-expansion cylinders, taking the place of steam cylinders in steam locomotives and driving directly the locomotive wheels.

While such locomotives possess most of the favorable features of the steam locomotive, i.e., high starting torque, good efficiency at all speeds, simple reversibility, good braking, they have their shortcomings such as limitation in power due to Diesel-engine limits and to problems linked to the use of reciprocating air compressors of high speeds.

In 1924, a locomotive of such type was built by the M.A.N. in Germany. At that time the use of air was suspect because it was feared that the lubricating oil might cause explosions in an air engine operating at high air temperatures. After exhaustive experiments had indicated these fears to be groundless, construction of a medium-size locomotive (for European conditions) was decided upon.

The single-stage piston air compressor for 100 psig, designed for water-injection cooling, presented the greatest problem. Other data were as follows: Type 4-6-4 (Hudson), 1000-hp continuous, 1200-hp short-time rating; temperature of the air in front of the locomotive engine 630/680

[3] Research Engineer, Manhasset, Long Island, N. Y.

deg F; tractive force 26,400 lb; drivers 63 in. diam; cylinders $27^1/_2$ in. × $27^1/_2$ in.; weight empty 260,000 lb; service weight 275,000 lb, including 4400 lb fuel; maximum speed 50 mph. (The rather large cylinders resulted from the choice of a comparatively low working pressure.)

The locomotive was put into operation in 1926. Official tests followed in 1929. The flexibility of this locomotive was found to be practically the same as that of a similar steam locomotive. Air explosions never occurred which were doubly safeguarded against by proper control of lubrication making accumulation of excess lubricating oil impossible.

As far as could be learned, two reasons stood in the way of wider acceptance of such a locomotive in Germany and elsewhere:

(*a*) The hesitation of the German Government Railway to rely too much on oil fuel which was not available within the country.

(*b*) The great difficulties with the water-injection-cooled piston compressor.

The power transmission by hot air as such was considered a complete success.

Having these facts in mind a new gas-turboengine locomotive (Nettel-Kreitner system) was conceived, in which the Diesel-piston compressor set is replaced by a gas turbine driving a rotating compressor, with a second-stage rotating compressor which receives its air from the discharge of the first compressor. The second compressor discharges air into an air heater and therefrom into the locomotive cylinders. This basic arrangement is shown in Fig. 5 of this comment, and hardly requires detailed explanation (patented). It is noteworthy, however, that this basic hook-up shows automatic torque-converter characteristics.

Such locomotives are suitable for powers from 2000 to about 6000 hp, and, with oil fuel, may be expected to show efficiencies in excess of 20 per cent referred to the piston rod of the locomotive engine.

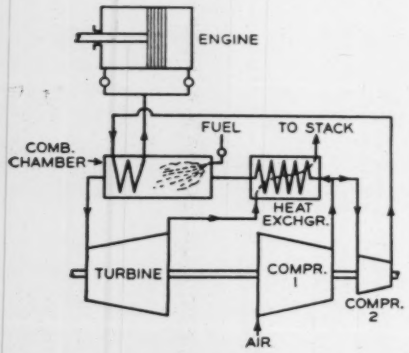

FIG. 5 SCHEMATIC DIAGRAM OF GAS-TURBO ENGINE LOCOMOTIVE

The N-K locomotive can be built for burning pulverized coal, either with internal combustion, if the recent efforts to remove the solid products of combustion should be successful, or in burners with external combustion. Coal may even be burned in bulk on grates with external combustion.

The N-K locomotive may be expected to show the following features:

1 Approximately the same performance characteristics in operation, reversing, and braking as steam locomotives.

2 Automatic torque-converter power transmission.

3 Approximately the same economic efficiency as Diesel-electric types of equivalent performance.

4 Radically lower weight and consequently, cost. (About one half the cost of Diesel-electric types.)

5 Radically shorter length. (About 95 ft for 5000 hp.)

6 Simplest possible control.

7 Low maintenance costs.

8 Highest availability.

Labor Relations in Textile Engineering

COMMENT BY J. W. NICKERSON[4]

Mr. J. J. McElroy's paper[5] sounds a timely warning. If the textile industry is to prosper in the face of future foreign competition, then surely its increase in productivity must at least keep pace with the increase in wages, which percentagewise has been more than in most industries. This means that technological improvement should proceed without interference.

There are some labor leaders who understand and have publicly stated that our need is for more and more production per man-hour; that to have more we must produce more. Unfortunately, they appear to be in the minority and, when a particular problem is to be faced, they are often not able to maintain their leadership against the pressure of their constituents.

As the author points out engineers need to realize to a greater extent than ever that the human relation is a major part of the advance in the engineering of production. They need to see to it that management calls for reasonable and equitable tasks and that labor understands it to be to its advantage to accomplish such tasks.

Textile management has brought much of its present difficulty upon itself. Decades ago, a few progressive textile companies thoroughly studied their equipment and operations and placed them on a wage-incentive basis. Others, in order to compete, assumed that they could use the same work assignments under entirely different conditions. Naturally, this led to grievances and labor difficulty, and finally to the general textile strike in 1934. To settle these issues, the President at that time established the "Textile Work Assignment Board." With labor and management in agreement this board came to the conclusion that standardized formulas, set up regardless of the tremendous variation in conditions existing in the industry would be unsound and unjust.

The following quotation from the report of the Silk Textile Work Assignment Board is significant:

"The Board is clear in its conviction that a rigid restriction as to the number of machines to be run or yards to be produced, even on the same fabric (and there are thousands of fabrics) would be unwise and unfair to workers and management alike. Work performed is not in proportion to machinery run, nor to pounds and yards produced; uniform piece rates per pound or yard, consequently, are unfair to workers as well as to management . . . . . .

"Work assignments, to be consistent, and if they are to be adjusted in the interests of employers and employees, must be expressed and measured not in terms of units of machinery, but in terms of actual work required."

Unfortunately, instead of using the best engineering advice and proceeding in a friendly and co-operative manner to make clear to labor the facts evolved by engineers, many companies still endeavored to increase their work assignments on the basis of opinion.

This fostered opposing opinions and eventually compromises through collective bargaining. The results, as the author points out, have been overtechnicalized contracts containing fixed and restrictive clauses concerning production problems which, for the sake of all concerned, should be purely the functions of management.

[4] Bigelow, Kent, Willard & Company, Boston, Mass. Member, A.S.M.E.

[5] "Labor Relations in the Textile Engineering Field," by J. J. McElroy, MECHANICAL ENGINEERING, vol. 68, April, 1946, pp. 344–346.

The implication at the end of the paper that the Wagner Act demands the inclusion of such technical clauses in contracts seems to be erroneous. It is certainly unfortunate that many managements have bound themselves with restrictive clauses.

Some textile firms have continued with scientific methods of measuring and paying for productive effort, and have kept this free as a management function, giving labor at the same time an understanding of its administration and an opportunity to appeal through the grievance machinery.

In order to succeed as a whole, the industry must proceed in this direction. The author is correct in urging that full use be made of engineers to develop this understanding.

COMMENT BY R. C. ASHWORTH, JR.[6]

It seems to the writer that in summing up his recommendation to the engineers, the author makes the problem of designing machinery, which labor will run, a direct responsibility of the engineers.

The writer's idea of the function of the engineer is to design the most efficient machine that he possibly can, and then adapt it to the operator whether it be male or female. No limitation on the imagination of an engineer should be imposed by the personal factor. This matter should be handled by those who are skilled in human relations and we have plenty of them in industry for this purpose.

In effect what the author is saying to the engineer is "go to the worker and ask him what type of machine he will run and how much effort he will put into it, and then design the machine to suit his answer."

COMMENT BY W. S. WARREN[7]

The author is to be complimented on the clarity of his presentation, as well as on the fairness with which he has described the problems confronting the mills today in their dealings with labor.

Recently, a conference was held at our plant in Providence, which in many respects dealt directly with the question of the adoption of improved machinery by the mills and the possibility of adequate return on such capital investment. Our conclusions are entirely in line with those of the author in that very careful engineering will be required in the future to assure attractive returns on such investments, and that the adoption of improved machinery by individual mills must coincide with adequate labor adjustments to make the operation of such machinery profitable and desirable.

The author has keynoted a subject which is of prime importance to every mill hoping to maintain a competitive position in the industry.

AUTHOR'S CLOSURE

Referring to R. C. Ashworth's remarks; the modern automobile is a good example of a machine designed to be operated with the least possible effort. The engineer actually went to the customer in proving this machine.

Textile machinery also can be made to operate with less physical and mental effort, especially in weaving. Parts can be made to assemble and adjust and hold adjustment better. The input of the operator and the maintenance man should be a major factor in design or improvements.

The other part of the problem is to get worker acceptance of the better machine and recognition of values involved. If, for example, a worker operates 30 old units with a certain physical and mental input, and this same input will handle 40 new units, the problem is to get labor to operate 40 units that will justify the capital expense involved in scrapping the old and replacing with the new more efficient machines.

The author is not in agreement with Mr. Ashworth that this phase of the matter is strictly a case of handling by those skilled in human relations. It is felt that the engineer is quite involved. He designed the machine, and if it does not prove to be more efficient with less labor input in the hands of the industry, it is a failure, and he should in this age consider the human factor more intensely in design of operating mechanisms that will improve the workers' efficiency by easier, safer, and more comfortable movements at the machine.

JOHN J. MCELROY.[5]

[5] General Superintendent, Maverick Mills, East Boston, Mass. Mem. A.S.M.E.

[6] President, Ashworth Bros., Inc., Fall River, Mass.

[7] New England Sales Agent, Universal Winding Company, Boston, Mass.

Science of Biomechanics

TO THE EDITOR:

As chairman of the third Biomechanics session of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS held during the 1945 Annual Meeting, the writer wishes to thank the society for the privilege of having the two professions meet to discuss problems pertaining to both. The possibilities of the mechanical-engineering and the surgical professions working hand in hand may prove to be of unlimited value to the good of mankind. It will be noted that the session was keynoted by the concentrated efforts to improve the plight of those who have sacrificed limbs in the service of their country.[9]

The first session in 1943, on biomechanics as a new approach to airplane safety represented an effort on the part of both professions to consider the airplane and its occupant as a single unit. The airplane was built around its personnel and the machine adapted to the man. Now that hostilities have ceased the Biomechanics Committee can be proud of the fact that the human toll for victory was materially reduced by its efforts.

We now attempt an even more difficult problem, namely, that of building a machine, in this case a prosthetic device, around an amputated human extremity. The history of prosthetic devices bears witness of the difficulties that will be encountered and the necessity of pioneer biomechanical work before the plight of the amputee can be materially improved. It is gratifying to know that the same group of surgeons who assisted airplane builders during hostilities is now leading the parade in endeavoring to relieve the sufferings of the victims of the conflict.

As a member of the surgical profession, may the writer sincerely congratulate this Society for its efforts in pioneering Biological Engineering, particularly through its subdivision of Biomechanics. Particular thanks are due to the chairmen of the sponsoring divisions and their associates whose hard work made such sessions as those of the last three years possible, and to the personnel of the armed forces, universities, and other organizations who have officially cooperated in this work.

CHARLES MURRAY GRATZ.[10]

[9] "Principles Involved in Prosthetic Devices," by Captain F. P. Kreuz and Capt. H. H. Montgomery, MECHANICAL ENGINEERING, vol. 68, July, 1946, pp. 630–631, 636. Also, "Problems in Design of Prosthetic Devices," by E. F. Murphy, ibid., pp. 632–636. Two additional papers were presented at the Biomechanical session of the 1945 Annual Meeting, as follows: "Limits of Factors of Safety in the Human Body," by E. F. Du Bois, ibid, pp. 625–627; and "Applying Biomechanics to Airplanes," by F. K. Teichmann, ibid, pp. 628–629.

[10] M.D., F.A.C.S., New York, N. Y.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Women in Industry

WOMEN IN INDUSTRY—Their Health and Efficiency. Issued Under the Auspices of the Division of Medical Sciences and the Division of Engineering and Industrial Research of the National Research Council. Prepared in the Army Industrial Hygiene Laboratory. By Anna M. Baetjer, Sc.D, Assistant Professor of Physiological Hygiene, School of Hygiene and Public Health, The Johns Hopkins University. W. B. Saunders Company, Philadelphia, Pa., and London, England, 1946. Cloth, 6 × 9 1/8 in., 344 pp., 35 figs., $4.

REVIEWED BY LILLIAN M. GILBRETH[1]

EVERY word on the title page of this valuable book is significant as establishing its importance and validity. Its 344 pages present material that would have been extremely useful during the war when the armed services and industry alike were facing the problems of using woman-power most effectively. This material should be equally useful today when the problems of placing and utilizing women successfully in peacetime demand intelligent solution.

This is a handbook and a textbook to be studied carefully and referred to often. It is also a book of interest to the general reader who wants to be adequately informed in this field. It is addressed primarily to the industrial physician and the personnel manager, and the departments which they head. But it speaks a language which everyone in industry who can ask questions in the areas that it covers can understand. It is not easy reading because it is filled with charts, graphs, tables, and collections of data. It also has many references which enrich the material but complicate the reading. But it is just this careful documentation and implementation that we have been needing.

The material is presented in seven sections which comprise a total of seventeen chapters of related material. The seventeenth chapter is a summary which can be read first by the reader who wants to locate quickly the material of special interest to him. There are four appendixes and an extended bibliography besides an index so that one can find and collect what he needs to know on any topic in the minimum of time. But it is to be hoped that no reader will stop with this, for the book pays richly for continuous and careful reading in its entirety.

It becomes evident as one reads, that much that we have thought was fact finding on women in industry was really opinion. We see that there is still much remaining to be done, but that we have an increasing amount of guidance to follow. Women are more like men than different from them, in their needs, in industry! Careful medical and personnel tests, placement, training, health and safety protection are needed by everyone.

Where the problems of women differ from men in their physiological and psychological aspects, we have, as yet, few definitive findings to guide us, and by and large tend toward what may be overprotection, which is surely better than neglect.

Dr. Baetjer has done a fine workmanlike job. It is to be hoped that we in industry will read, study, and use what she has given us.

A few quotations may illustrate the pithy findings interspersed among the detailed accounts of the investigations.

"Heavy women are often not the strongest," p. 13. . . . . "If the operation of the machine cannot be adjusted to fit the size of the woman assigned to the job, then it becomes necessary to fit the size of the woman to the machine," p. 19 . . . . "Women should be instructed how to lift a load to avoid strain," p. 21. "In general, the same personnel policies apply equally to men and women," p. 30.

Supervisors: "In general, it would seem that the personality and ability of the person are more important than the sex," p. 32. . . . . "The Industrial physician becomes the public health officer of the plant," p. 101. . . . . "Except for their inexperience in general, women did not present any greater accident problem than men" (during the war), p. 107. . . "The most important measure for preventing accidental injuries among all employees is their proper training in safe working methods, beginning with the first day of their employment," p. 123 . . . . "It is apparent therefore that there is little evidence to support the opinion that normal women are more susceptible to the toxic substances encountered in industry than men," p. 151.

Such quotations are useful to stimulate a full and careful reading of this book. It would be a misuse of them to use them to further one's preconceived notions—they deserve to be read in their context and to be used for evidence, not propaganda.

[1] President, Gilbreth, Inc., Montclair, N. J. Fellow, A.S.M.E.

Income From Independent Professional Practice

INCOME FROM INDEPENDENT PROFESSIONAL PRACTICE. By Milton Friedman and Simon Kuznets, National Bureau of Economic Research, New York, N. Y., 1945. Cloth, 6 × 9 in., 599 pp., tables, charts, $4.50.

REVIEWED BY S. LOGAN KERR[2]

THE title of this book might lead one to believe that the text would show how to build up a practice and an income. This, however, is not the case, as the book deals entirely with a statistical analysis stemming from some special questionnaire studies by the Department of Commerce of the United States for the period from 1929 to 1936.

The language used in the book is that peculiar to statisticians and the treatment is mathematical. The analysis deals with replies received from members of the medical, dental, legal, accounting, and a small portion of the consulting engineering profession.

Chapter 1 discusses the general features and characteristics of the five professions under consideration. In this chapter, in several places, the statement is made that consulting engineers are the only ones of the five professions not licensed by the various states. This, obviously, is incorrect as anyone designing structures or projects which affect the public health or safety is required to be a registered engineer and to qualify under the laws of the state. In practically every state in this

[2] President, S. Logan Kerr & Co., Inc., Philadelphia, Pa. Mem. A.S.M.E.

country and every province in Canada there are more or less rigid requirements which have to be met by an engineer for him to be registered and practice his profession.

In chapter 2 it is interesting to note that the sampling was based on reports from about 13,000 people out of an estimated 300,000 in independent professional practice. This is about a 4 per cent sampling and it is questionable whether the conclusions arrived at are sound, in view of the very small coverage of the various professions and particularly the consulting engineering field.

Table 4 shows that only about 50 per cent of the questionnaires returned were usable in the survey and they represented slightly less than 5 per cent of the total members of the five professions.

There is detailed discussion of the costs of training for entry into the professions which would indicate that the consulting-engineering practice requires much less training than the medical or legal profession. The variation in financial return as a function of geography is of interest, but the results shown in the book do not correspond with surveys made by the national engineering societies, in which the effect of the geographic location is quite different from that indicated in this book.

The charts and tabulations showing the variation in income of consulting engineers with time are based on one set of questionnaires sent out in 1933 to cover the period from 1929 to 1932, and indicate that their income dropped off very abruptly in 1929–1932. The consulting engineers are concerned, primarily, with the design of structures representing capital expenditures. When economic conditions in the country are such that there is a great deal of construction and expansion, a consulting engineer is busy. When this activity decreases or disappears altogether, as it did do in increasing extent over this four-year period, the activities of consulting engineers decreased and hence their earnings are affected; this is known to be independent of experience, geography, or location.

It is questionable whether engineers and professional men can gain much from reading this book, as it is merely a statistical review and the results have been derived from a small sampling over a very limited period.

Books Received in Library

APPLIED PHOTOGRAMMETRY. By R. O. Anderson. Fourth edition. C. E. Hayes, P.O. Box 882, Chattanooga 1, Tenn.; apply Edwards Brothers, Ann Arbor, Mich., 1946. Cloth, 6 × 9 1/4 in., 517 pp., illus., diagrams, charts, tables, $6. As in the previous editions of this book the object is to present a clear, simple, but accurate method of calculating tilt of the aerial photograph. In this new edition has been incorporated the material contained in two other books by the same author, "Rigorous Analysis of the Scale Point and Tilt Formulas" and "Tilt of the Aerial Photograph by Graphical Resection." The theory and demonstrations of the basic idea, the dropped-perpendicular analogy, have been extended, with further derivations, to increase the accuracy of the result. Numerical examples and sample calculations have been used freely, adding to the practical value of the book.

INDUSTRIAL RESEARCH 1946. Advisory Editor, E. N. da C. Andrade. Todd Publishing Co., London, England, and New York, N. Y., Sole British Distributors: Geo. G. Harrap & Co., Ltd., 1946. Cloth, 5 1/2 × 9 in., 736 pp., $6. This British reference book presents first some thirty brief articles by specialists on various aspects—technical, educational, financial, etc., of the important fields of industrial research. Succeeding sections contain classified directories of official trade and technical research organizations in Great Britain, and also lists of university and industrial research laboratories. A section discussing careers in industrial research includes courses available in universities and membership requirements for technical societies. There are extensive classified lists of books, periodicals, and films, and a "Who's Who" in British industrial research.

INSTRUMENTS AND PROCESS CONTROL. New York State Vocational and Practical Arts Association, Albany, N. Y.; distributed by Delmar Publishers, Inc., Albany, N. Y., September, 1945. Paper, ring binder, 8 1/2 × 11 in., 233 pp., illus., diagrams, charts, tables, $2.75. The general principles of process control are discussed, and a large number of instruments for specific control operations are described and illustrated. Mechanical, electrical, hydraulic, and pneumatic control methods are included, and the name of the manufacturer is given for each instrument shown. There is a glossary and separate chapters are devoted to installation, adjustments, checking and testing procedures, and advanced control theory.

LE ZINC ET SES ALLIAGES. By R. Grunberg, M. Maréchal, H. Patin, E. Wagner, preface by A. Portevin. Dunod, Paris, France, 1946. Paper, 6 1/2 × 9 3/4 in., 233 pp., illus., diagrams, charts, tables, 500 fr. The author first deals with the methods of extraction of zinc and with its characteristics and uses. After a brief chapter on the mechanical properties of rolled zinc, considerable space is devoted to zinc alloys, including casting methods. Welding and brazing are dealt with, corrosion characteristics are discussed, and methods of analysis are described.

METALLURGY OF STEEL CASTINGS. By C. W. Briggs. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1946. Cloth, 5 1/2 × 9 in., 633 pp., illus., diagrams, charts, tables, $6.50. The object of this book is to provide a reference work for the technical control of manufacturing operations for the production of steel castings. It correlates the problem of the casting of steel with the methods of steel manufacture, and considers in addition the following related topics: gases, deoxidation, and inclusions; tapping and pouring; gates and risers; properties of liquid cast steel; solidification; hot-tear formation; molding sands and cores; and the welding of steel castings.

MÉTROLOGIE GÉNÉRALE (Grandeurs et Unités). By M. Denis-Papin and J. Vallot. Dunod, Paris, France, 1946. Fabrikoid, 4 × 6 in., 428 pp., plates L-XLVI, tables, diagrams, charts, 240 fr. This comprehensive manual covers the field of measurement from a broad point of view. Early chapters are devoted to a discussion of measurement in general, the international system of weights and measures, and the symbols and equations of fundamental systems of measurement. Methods of measurement and units are described for the fields of geometry, geography, mechanics, angular measure, stresses, electricity and magnetism, heat and radiant energy, optics and time, as well as for simple everyday use. Special industries, ancient and foreign units are covered. A detailed subject index provides a key to the wealth of information. A second volume will deal with measuring instruments and their use.

OFFICE LIBRARY OF AN INDUSTRIAL RELATIONS EXECUTIVE, 1946, prepared by H. Baker. Fifth edition. (Bibliographical Series No. 77.) Princeton University, Industrial Relations Section, Princeton, N. J., March, 1946. Paper, 6 × 9 in., 36 pp., $0.50. A considerable list of recommended books and pamphlets for the industrial-relations executive is presented under the following general headings: General works; specific personnel problems and programs; trade unions and collective bargaining; labor legislation and administration; social insurance. A section of additional sources of information lists periodicals, research organizations, commercial and government informational services.

PERSONALITY AND ENGLISH IN TECHNICAL PERSONNEL. By P. B. McDonald. D. Van Nostrand Co., Inc., New York, N. Y., 1946. Cloth, 5 1/2 × 8 3/4 in., 424 pp., $3.75. This book emphasizes the importance of developing a definite personality, an accurate command of English, and effective methods for presenting ideas, both written and verbal, with specific suggestions for improvement in these particulars. The value of a reasonably broad cultural as well as technical background is brought out, and several chapters offer material for increasing one's general knowledge.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

A.S.M.E. 1946 Annual Meeting to Be Held at Hotel Pennsylvania, New York, N. Y., Dec. 2–6, 1946

Theme: The Public Responsibility of the Engineer

ALTHOUGH more than 12 months of peace have done little to calm the troubled waters of statesmanship, they have brought order and certainty to the program-making activities of the Society. With the recollection still fresh of the "on again, off again" uncertainty associated with the annual meeting of last year and the hectic last-minute transfer of the annual banquet from the Hotel Pennsylvania to the Hotel Astor, it is a pleasure to report in some of the tones of finality that the 1946 Annual Meeting of The American Society of Mechanical Engineers will be held at the Pennsylvania Hotel, New York, N. Y., Dec. 2 to 6, 1946, and particularly that the Annual Banquet will be held in the same hotel on Wednesday, Dec. 4.

In recognition of the place engineers deserve to hold on councils other than those concerned solely with technical matters, President D. Robert Yarnall has announced that the theme of the 1946 Annual Meeting will be "The Public Responsibility of the Engineer."

Speakers prominent in the fields of engineering and public life have been invited to speak on various phases of this subject and the A.S.M.E. Citizenship Committee has scheduled one session during which members will be invited to participate in general discussion.

Reservations

Several events scheduled in New York, N. Y., during the month of December, 1946, indicate that the most important advice that can be given to members at this time regarding arrangements for the Annual Meeting is to urge them to send in requests immediately for room reservations at the Hotel Pennsylvania or to any other hotel or club they prefer.

Not only does the technical program of the Annual Meeting promise a record attendance, but the 1946 National Power Show will be held in New York City during the same week. If the United Nations Assembly does meet in New York City as currently planned, engineers will have to compete against experienced diplomats of the world for a place to hang their hats.

Cushing, New York

DOWNTOWN FINANCIAL DISTRICT TOWERS AND THE EAST RIVER. CABLES AT EXTREME RIGHT ARE THOSE OF THE OLD BROOKLYN BRIDGE

Program

Professional Divisions, Groups, and Technical Committees have announced intentions to sponsor more than 75 technical sessions. The Committee on Meetings and Program is now studying the problem of how to fit so many sessions into the limits of a five-day meeting. It is expected that the final events on the program will approach in number those held during the 1945 Annual Meeting.

The tentative program will be published in the November issue of MECHANICAL ENGINEERING.

Here is an idea of what the program will contain in the way of technical sessions: Applied Mechanics Division, five sessions; Aviation Division, five sessions; Heat Transfer Division, five sessions; Power Division, three sessions; Management Division, five sessions; Process Industries Division, three sessions; and many others. In addition to sessions sponsored by Professional Divisions and Groups, ten A.S.M.E. Research Committees will sponsor about 15 sessions during which they will report on progress.

National Power Show

The 17th National Exhibit of Power will be held at the Grand Central Palace, Dec. 2 to 7, 1946. The list of innovations promised and the number of exhibitors who have contracted for space indicate that the 1946 National Power Show will be the largest ever held.

Honors and Awards

During the Annual Banquet the following honors will be conferred:

Holley Medal to Norman Rothwell Gibson, Member A.S.M.E., vice-president, Buffalo Niagara Electric Corporation, Buffalo, N. Y., "for achievements and inventions which have advanced the sciences of hydraulics and hydromechanics, including an original method of water measurement which made possible more accurate testing of large hydroelectric generating units."

Cushing, New York

CENTRAL PARK IN NEW YORK CITY

Melville Prize Medal for Original Work to Troels Warming, Jun. A.S.M.E., Diesel engineering division, Harnischfeger Corporation, Port Washington, Wis., for his paper, "Polar Diagrams for Tuning of Exhaust Pipes."

Junior Award to Martin Goland, Jun. A.S.M.E. chairman, engineering mechanics research, Midwest Research Institute, Kansas City, Mo., for his paper, "The Flutter of a Uniform Cantilever Wing."

Honorary Membership to Alexander Graham Christie, fellow and past-president, A.S.M.E., professor of mechanical engineering, Johns Hopkins University, Baltimore, Md., and to Lewis Ketcham Sillcox, fellow A.S.M.E. and A.S.M.E. Medalist, vice-president, New York Air Brake Company, Watertown, N. Y.

Women's Activities

The Woman's Auxiliary to the A.S.M.E. has planned a five-day program for the wives of members and guests who are planning to attend the 1946 Annual Meeting. The program includes a visit to the United Nations Headquarters at Flushing and Lake Success, a visit to the Dumont Television Studio, to the Statue of Liberty, and the Museum of Natural History, as well as many social events.

A detailed program of the events planned for women attending the meeting is in preparation. Copies may be obtained by writing to the Secretary.

1946 A.S.M.E. Membership List Mailed to All Members

A COPY of the new A.S.M.E. Membership List was mailed in September to every member of the Society entitled to receive publications. Published as Section Two of the August Transactions, it was sent with that issue to all those on the Transactions mailing list. It was mailed separately to all others. Anyone failing to receive his copy should advise the Secretary of the A.S.M.E., 29 West 39th St., New York 18, N. Y., promptly in order to obtain one without charge.

Atomic Energy Act of 1946 Signed by President Truman

THE McMahon Bill for the control of atomic energy (S. 1717), introduced in the Senate by Brien McMahon, senator from Connecticut, on Dec. 20, 1945, was signed and made into law by President Truman on August 1, 1946. The law provides for a civilian-dominated commission and incorporates many of the suggestions urged by the Engineers Joint Council. The law will be known as the "Atomic Energy Act of 1946."

The McMahon Bill was discussed by Senator McMahon at the Nuclear-Energy Application Dinner held during the A.S.M.E. Semi-Annual Meeting in Detroit, Mich., June 17, 1946. Senator McMahon's talk was published on pages 782 to 784 in the September issue of MECHANICAL ENGINEERING.

The main points of the Atomic Energy Act of 1946 follow:

Organization

The law provides for an Atomic Energy Commission composed of five full-time civilian members who will decide policy; a general manager who will administer the Commission's program; and four directors of the following technical divisions: Research, production, engineering, and military application.

The commissioners and the general manager will be appointed by the President, but the Commission will designate the directors of the various divisions. The law specifies that the director of the Division of Military Application will be a member of the Armed Forces.

A General Advisory Committee, composed of nine civilians appointed by the President for a term of six years, will advise the Commission on scientific and technical matters. This committee will meet at least four times a year.

A Military Liaison Committee, appointed by the Secretaries of the Army and Navy, will consult with the Commission on matters pertaining to military applications.

Research

Recognizing the need for continued progress in science, the law directs the Commission to conduct research and development activities by private or public institutions or persons in specific fields of activity. These are:

(1) Nuclear processes.

(2) The theory and production of atomic energy, including processes, materials, and devices related to such production.

(3) Utilization of fissionable and radioactive materials for medical, biological, health, or military purposes.

(4) Utilization of fissionable and radioactive materials and processes entailed in the production of such materials for all other purposes, including industrial uses.

(5) The protection of health during research and production activities.

To achieve these ends the law authorizes the Commission to make contracts, agreements, grants-in-aid, and loans for the conduct of research and development activities.

Production of Materials

The Act provides for an absolute Government monopoly of production and ownership

Cushing, New York

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of fissionable materials, except for small facilities or materials such as may be useful in the conduct of research or which, in the opinion of the Commission, are not sufficiently large to produce an atomic weapon.

Control of Materials

The transfer of fissionable materials from or into the United States, as well as the possession or transfer of such materials within the United States, is forbidden by the law except as authorized by the Commission. Widespread independent research and development activities are assured by a provision authorizing the Commission to distribute fissionable materials with or without cost to persons or institutions for research, medical therapy, or use under license.

All movement of fissionable materials after they have been removed from the place of deposit in nature will require a license from the Commission. Small quantities of source materials, which may be considered unimportant in the opinion of the Commission, will require no license for possession or transfer.

Control of Information

The Commission is directed to control the dissemination of restricted data in such a manner as to assure the common defense and security and in accordance with the following principles:

(1) That until Congress declares by joint resolution that effective and enforceable international safeguards against the use of atomic energy for destructive purposes have been established, there shall be no exchange of information with other nations with respect to the use of atomic energy for industrial purposes; and

(2) That the dissemination of scientific and technical information relating to atomic energy should be permitted and encouraged so as to provide that free interchange of ideas and criticisms which is essential to scientific progress.

Patents and Inventions

Inventions and discoveries useful solely in the production of fissionable materials or in utilization of such materials for military weapons are declared by the law not patentable, and no patent, issued in the future, which may prove useful in the fields of research and development activity specified by the law, shall confer any rights to the owner with regard to such use.

Any patent granted by the government may be declared in the public interest by the Commission if it utilizes or is essential in the utilization of fissionable materials or if the Commission should decide that it must be licensed to effectuate the policies or purposes of the Act.

Licensing of Patents

In order to make peacetime benefits of atomic energy as widely available as possible the Commission is authorized to grant licenses which carry the right to use patents which the Commission has declared to be affected with the public interest. The use of such patents is subject to payment of reasonable royalty fees agreed upon by the owner and the licensee, or determined by the Patent Compensation Board composed of two or more employees of the Commission. Owners applying for an award or fee can be represented by counsel and all the Commission's decisions in this respect are subject to judicial review.

Metropolitan Section Junior Group Announcement

The Junior Group of the A.S.M.E. Metropolitan Section will hold its first meeting of the 1946–1947 season in the form of a Smoker at the George Washington Hotel, 23rd St. and Lexington Ave., New York, N. Y., on Tuesday, Oct. 15, 1946. Here is your opportunity to meet the other members of your Society in the cordial, informal atmosphere of a smoker. The program includes a full-course dinner, starting at 7:00 p.m., with free beer and smokes, plus a schedule of entertainment which promises a very enjoyable evening for all. Tickets are $3 per person and may be secured by writing Miss Muriel England, Headquarters, A.S.M.E., 29 West 39th St., New York 18, N. Y.

Illinois Tech Graduate School Has New Dean

WILLIAM A. LEWIS, JR., research professor of electrical engineering, Illinois Institute of Technology, has been appointed dean of the Graduate School of the Illinois Institute of Technology.

Dr. Lewis succeeds Dr. Linton E. Grinter, member A.S.M.E., who resigned his administrative responsibilities to devote his time to teaching and research. Dr. Grinter participated in the Sixth International Congress for Applied Mechanics in Paris last month as a representative of the Illinois Institute of Technology.

Engineers Notify Public of Professional Status

THE professional status of engineers in Pennsylvania under a new statute, which became effective, June 30, 1946, was called to the attention of the public by a notice published in *The Philadelphia Inquirer* by the Pennsylvania Society of Professional Engineers.

The notice referred to Act No. 367 of 1945 of the Pennsylvania Legislature, which states that "it is unlawful for any person to engage, or to offer to engage, in the practice of engineering in this Commonwealth unless he is licensed and registered under the laws of this Commonwealth as a professional engineer."

Practicing engineers were informed that they must be licensed and registered in order to continue practice under the new law. The notice added, "If you are not registered, do not practice or assume the title 'engineer' with or without qualifying adjectives."

The notice informed the public that the new law was designed to safeguard its life, health, and property and urged the public to cooperate in the enforcement of the law by reporting all violations.

A.S.M.E. Safety Committee Holds Meeting on Safety Studies in Colleges

BECAUSE it was concerned over lack of adequate safety instruction in American universities and schools of engineering, the Safety Committee of The American Society of Mechanical Engineers invited engineering teachers from leading colleges of engineering in the New York Metropolitan area to meet in New York, N. Y., Aug. 8, 1946, for the purpose of exploring methods by which safety information and safety procedures developed by industry could be efficiently routed to lecture halls and integrated with existing courses of engineering study.

Safety Instruction Urged

Harry W. Gabor, chairman, A.S.M.E. Safety Committee, solicited the "aid, advice, and good counsel" of the engineering teachers who attended the meeting, in a campaign to reduce the tremendous toll of accidents which produced 96,000 fatalities in the United States in 1945.

W. F. O'Connor, professor, College of Engineering, New York University, suggested that safety studies could best be advanced if engineers in the field would make the latest safety methods developed by industry available to college teachers, who could use this information in their lectures whenever the opportunity presented itself.

Because every good engineer is a safety engineer, Dr. O'Connor stated that such a method was preferable to the introduction of still another course into the crowded curriculum of engineering study.

Personnel of Committee

A five-man advisory committee of engineering teachers was chosen to work with the A.S.M.E. Safety Committee in further study of the problem. This Committee is composed of the following: W. F. O'Connor, chairman, New York University; Arthur Lesser, Jr., Stevens Institute of Technology; Cornelius Wandmacher, Polytechnic Institute of Brooklyn; J. E. Englund, Columbia University; and William Cutter, New York University.

Members of the A.S.M.E. Safety Committee are: Harry W. Gabor, chairman, Edward R. Granniss, Jesse J. Zeitner, Frederick J. Graf, and Herbert W. Heinrich.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, August 29, 1946

A MEETING of the Executive Committee of the Council was held in the rooms of the Society, Aug. 29, 1946. There were present: D. Robert Yarnall, chairman; J. Noble Landis; A. R. Mumford (Sections); K. W. Jappe, treasurer; C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Change Section Name

Upon recommendation of A. C. Chick, vice-president, A.S.M.E. Region I, approval was voted for a change in name of the Bridgeport Section to the Fairfield County Section.

Metal Cutting Data Sheets

The first two issues of the Metal Cutting Data Sheets, mailed to subscribers in July and August, were reviewed with interest by the Committee.

Certificates of Award

It was voted to approve Certificates of Award for the following: L. C. Morrow, who served as chairman of the Manufacturing Engineering Committee; G. J. Nicastro, who resigned as chairman of the Education Committee of the Metropolitan Section; L. C. Straub, M. S. Wunderlich, L. C. Sprague, W. H. Erskine, R. W. Jones, Jr., E. S. Howard, retiring chairmen of Minnesota Section; and Theodore Eserkaln, Russell Smith, John E. Schoen, Robert J. Cramer, Theodore A. Wetzel, retiring chairmen of Milwaukee Section.

Deep Regret Expressed

The Committee noted with deep regret the death on Aug. 28, 1946, of Alexander R. Stevenson, Jr., member of the Executive Committee, and the death on Aug. 19, 1946, of B. V. E. Nordberg, nominee for director.

United Engineering Trustees, Inc.

Upon recommendation of the Committee on Organization, it was voted to appoint K. W. Jappe A.S.M.E. representative on the United Engineering Trustees Board for a four-year term.

Engineering Foundation Board

The resignation of W. Trinks as A.S.M.E. representative on the Engineering Foundation Board was accepted and upon recommendation of the Research Committee and the Committee on Organization, it was voted to appoint J. F. Downie Smith to fill the unexpired term ending in 1948.

Appointments

The following appointments were approved for the record:

Special Research Committees: Cutting Fluids, D. W. Murphy; Lubrication, Joseph J. Mikita.

Boiler Code Subcommittees: Boilers of Locomotives, R. P. Johnson, J. E. Davenport, and A. J. Townsend; Unfired Pressure Vessels, A L. Brown and E. O. Bergman.

Sectional Committee on Standardization of Plain and Lock Washers, Frank P. Tisch.

Planning Committee of Nuclear-Energy Application Committee: Physical Chemistry, H. S. Taylor; Biology, W. E. Chamberlain; Nuclear Physics, J. R. Dunning; Public Utility, K. M. Irwin; Naval Research, H. G. Dyke, U.S.N.R.; Electronics-Physics, A. O. C. Neir; and Manhattan Engineer District, Maj. Gen. T. F. Farrell.

Tellers of Election of 1947 Officers, W. G. Christy, F. M. Gibson, C. W. Obert; alternate, H. A. Lardner.

National Council of State Boards of Engineering Examiners, W. G. Christy.

Committee on Certificate of Award, A. R. Mumford.

R. E. Zimmerman Honored by A.S.M.

THE American Society for Metals has elected Rufus E. Zimmerman, vice-president in charge of research and technology, United States Steel Corporation, New York, N. Y., to receive the Society's Medal for the Advancement of Research for 1946.

Award of the Medal will be made at the annual banquet of the A.S.M. to be held in Atlantic City, N. J., Nov. 21, 1946.

Georgia Tech Library Made Depository of Wartime Research Reports

THE library of the Georgia School of Technology has been designated a depository for approximately 35,000 reports on wartime research by the Office of Scientific Research and Development.

The reports, now being removed from the Government's secret list, range from small pamphlets to large treatises and cover all fields of science.

The first shipment of reports, numbering about 1000 and covering the fields of electronics and radar, has already been received from the Radiation Laboratory at the Massachusetts Institute of Technology. The complete shipment is expected within six months to a year.

C. E. Hoyt Retires From A.F.A.

THE American Foundrymen's Association has announced the retirement of Charles E. Hoyt, who has served the Association for nearly 30 years in the offices of secretary, convention and exhibits manager, executive vice-president, and treasurer.

1947 A.S.M.E. Mechanical Catalog and Directory Out

800 Pages of Information

THE thirty-sixth annual A.S.M.E. Mechanical Catalog and Directory, 1947 edition, will be distributed to A.S.M.E. members during October.

In its catalog section, manufacturers describe and illustrate many products of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to the following markets: Metals and alloys, power-plant equipment, power-transmission equipment, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning equipment, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page-reference system in the Directory ties in with the catalog section providing descriptions of the desired machine or equipment.

According to the editors of the volume, it is the only book which covers the field of mechanical engineering so thoroughly.

A 16-page insert describing all A.S.M.E. publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of A.S.M.E. members.

Note to A.S.M.E. Section Secretaries

THE activities of your Section are placed on permanent record when they are published in the A.S.M.E. News section of MECHANICAL ENGINEERING. The ideas of your Section are interesting and helpful to others. They deserve national publicity.

When meetings are not reported, or are reported too late for publication, or are inaccurately reported, the efforts of your members may go unrecognized and unrewarded.

You are urged to report meetings promptly so that accounts of them can be published in the earliest possible issue of MECHANICAL ENGINEERING. Material must be at headquarters one month in advance of the month of issue. For example, all news for the December issue must be at headquarters on or before November 1.

You are urged to be accurate. Report full names of speakers, positions, company affiliations, and the titles of papers.

Your co-operation will make the A.S.M.E. news in this section of MECHANICAL ENGINEERING, timely, accurate, and helpful.

ARTIST'S SKETCH OF THE $100,000 NEW HEADQUARTERS OF THE ENGINEERS' SOCIETY OF MILWAUKEE

Milwaukee Engineers Open New Headquarters

A WEEK of feverish activity climaxed by a banquet at the municipal auditorium with Charles F. Kettering, member A.S.M.E., A.S.M.E. Medalist, vice-president, General Motors Corporation, as high-light speaker, is the way Milwaukee engineers celebrated the opening of their new headquarters. Approximately 1600 engineers and friends attended the dedication dinner on September 21, 1946, to hear Dr. Kettering talk on "The Challenge and Opportunities of Tomorrow."

In 1944 the Engineers' Society of Milwaukee purchased an elegant old home built by Frederick Pabst of Pabst Brewery fame. A campaign throughout industry of the area successfully raised a fund of $100,000 to defray the cost of remodeling and equipping the building. The interest displayed in this project by more than 100 contributing firms is a tribute to the forward-looking policy of American industry.

Influence Widely Felt

Founded in 1904, the Engineers' Society of Milwaukee has grown from a handful to a membership of 1366 engineers of the Milwaukee area. Embracing all the fields of engineering practice, the society's purpose is to improve the knowledge, technical skill, and social usefulness of those engaged in the engineering profession. In keeping with this purpose the society sponsors monthly meetings, with an outstanding nationally known member of the engineering profession as guest speaker, discussion groups which feature symposiums on leading civil or technical topics of the day, and studies of civic items on the behalf of government bodies for the purpose of presenting an unbiased technical opinion.

Among the affiliated groups are the Milwaukee Chapters of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, American Society of Civil Engineers, American Society of Refrigerating Engineers, American Society of Heating and Ventilating Engineers, the Institute of Radio Engineers, and the Illuminating Engineering Society.

C. F. Kettering Honored by Home Town

CHARLES FRANKLIN KETTERING, member A.S.M.E., A.S.M.E. Medalist, 1940, and vice-president in charge of research, General Motors Corporation, was hailed by more than 4000 friends, relatives, and business associates who gathered in his home town of Loudonville, Ohio, on Aug. 29, 1946, to celebrate his seventieth birthday.

Among those who attended the luncheon that opened the day's events were: Orville Wright, honorary member A.S.M.E.; Edward A. Deeds, associate member A.S.M.E., chairman of the board, National Cash Register Company; William S. Knudsen, honorary member A.S.M.E., director, General Motors Corporation; and George W. Codrington, member A.S.M.E., vice-president, General Motors Corporation.

In a brief talk Mr. Kettering recalled that he was born the year this country celebrated its centennial. In its 170 years, "due to our competitive system, we've gone to the top among all nations in productivity," he said.

"Now, we're feeding the nations and saving the world," he went on. "That isn't the work of any one person or any one place. It's being done by 10,000 little communities across the country, communities like Loudonville."

Mr. Kettering is an official or director of eight corporations, holder of honorary degrees from seventeen universities, and a member of many scientific and engineering societies.

Speaking to his friends he said, "A man must have a certain amount of intelligent ignorance to get anywhere."

Applied Mechanics Degree Offered by Brooklyn Polytechnic Institute

A NEW course of graduate studies leading to the degree of master of science in applied mechanics has been established at the Polytechnic Institute of Brooklyn, N. Y., was announced by Dr. H. S. Rogers, president of the Institute.

The new curriculum will be administered by the expanded department of aeronautical engineering under the new title of the department of aeronautical engineering and applied mechanics, and will make available to graduate engineers a broad knowledge of the principles of mechanics.

Dr. R. P. Harrington heads the new department. Others on the faculty are: H. J. Reissner, member A.S.M.E., N. J. Hoff, and P. A. Libby.

S. B. Ely Elected President of S.P.A.A.

SUMNER B. Ely, member A.S.M.E., superintendent of smoke regulation, Pittsburgh, Pa., was elected president for 1946–1947 of the Smoke Prevention Association of America, Inc., at the 39th annual meeting of the Association, held at the Nicollet Hotel, Minneapolis, Minn.

Eugene D. Benton, member A.S.M.E., Battelle Memorial Institute, Columbus, Ohio, was elected first vice-president.

A.S.M.E. Calendar

of Coming Meetings

October 7–9, 1946
Meeting of Petroleum Committee of Process Industries Division
Tulsa, Okla.

October 24–26, 1946
Joint A.I.M.E. Coal and A.S.M.E. Fuels Division Meeting
Philadelphia, Pa.

December 2–6, 1946
A.S.M.E. Annual Meeting
New York, N. Y.

Frank Whittle Named for Guggenheim Medal

THE Daniel Guggenheim Medal Board of Award announces its election of Air Commodore Frank Whittle, Royal Air Force, Great Britain, to receive the 1946 Daniel Guggenheim Medal for Achievement in Aeronautics. The specific citation reads, "for pioneering the development of turbo-jet propulsion of aircraft."

The first successful jet engine was developed by Air Commodore Whittle in 1937 and it was first applied to aircraft in 1941. As a contribution to the war effort, Air Commodore Whittle gave the patent rights to his invention and development to the British Government, and as an ally of the British, these rights became available to the United States.

The Daniel Guggenheim Medal was created for the purpose of honoring persons who make notable achievements in the advancement of aeronautics. It is also a commemoration of the support given by Daniel Guggenheim to the advancement of civil aviation. Provision for the Medal was made in 1928 by the gift of a fund from the Daniel Guggenheim Fund for the Promotion of Aeronautics. This fund is in the custody of United Engineering Trustees, Inc.

The Board of Award is composed of a representative of the custodian, three men appointed by each, The American Society of Mechanical Engineers, the Society of Automotive Engineers, and the Institute of the Aeronautical Sciences, and the American recipients of the Medal. The Medal is of gold and is awarded not more often than annually, with no restriction on account of race, color, nationality, or sex. Previous medalists include Orville Wright, William Edward Boeing, Donald W. Douglas, Glenn L. Martin, James H. Doolittle, Lawrence D. Bell.

W. Beattie and N. A. Parker Take Over New Posts

WAYNE BEATTIE, member A.S.M.E., has been appointed acting head of the mechanical engineering department of the University of Colorado. He replaces Norman A. Parker, member A.S.M.E., who has assumed duties as head of the mechanical engineering department of the University of Illinois.

I.M.S. to Hold Time and Motion Study Clinic

THE tenth annual National Time and Motion Study Clinic, sponsored by the Research Division of the Industrial Management Society, will be held November 7 and 8, 1946, at the Continental Hotel, Chicago, Ill. Theme of the clinic will be "Productivity Creates Wages."

Inquiries may be addressed to the Industrial Management Society, 176 West Adams St., Chicago 3, Ill.

AIR COMMODORE FRANK WHITTLE, WHO BUILT THE FIRST SUCCESSFUL AIR-JET ENGINE, HONORED AT LUNCHEON IN NEW YORK ON SEPT. 3, 1946

(*Standing, left to right:* W. S. Morris, vice-president in charge of sales, American Locomotive Company; J. E. Davenport, vice-president, American Locomotive Company; George A. Stetson, editor, MECHANICAL ENGINEERING; R. T. Sawyer, chairman, Gas-Turbine Co-Ordinating Committee, A.S.M.E. Oil and Gas Power Division; O. B. Schier, meetings and divisions assistant, A.S.M.E. *Seated, left to right:* F. K. Teichmann, chairman, A.S.M.E. Aviation Division; G. Edward Pendray, secretary, American Rocket Society; Air Commodore Frank Whittle, British Air Service, 1946 Daniel Guggenheim Medalist; and E. J. Kates, chairman, A.S.M.E. Oil and Gas Power Division, director at large, A.S.M.E.)

Union Aids Shipment of Technical Papers

DESPITE late printing and a series of strikes that froze most of the trucking and pier-handling facilities in New York on Sept. 3, 1946, 22,000 copies of papers preprinted by the A.S.M.E. for the International Technical Congress, Paris, Sept. 16 to 21, were delivered to the liner *Queen Mary*, the last ship leaving New York which could arrive in France in time for the Congress.

Although the truckers' strike was already in progress, the union made an exception of the 900-lb shipment and allowed the papers to be delivered to the head of the pier. Here, 400 ft from the ship which was preparing to sail in order to avoid the threatened seaman's strike, the material was again held up. This time it was a jurisdictional misunderstanding.

Before three A.S.M.E. staff members could haul the bundles by hand truck to the loading gangway, the atmosphere cleared and the material was placed aboard ship.

There was relief at Headquarters when the *Queen Mary* sailed down the bay six hours before the officially scheduled departure.

W. Julian King Joins Faculty of Cornell University

W. JULIAN KING, member A.S.M.E., research engineer, Battelle Memorial Institute, Columbus, Ohio, and authority on combustion and gas turbines, has been named director of the Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y.

Mr. King succeeds W. N. Barnard, member A.S.M.E., professor of mechanical engineering, emeritus, who retired June 30, 1946.

Author of many professional articles, Mr. King is best known for his papers on "The Unwritten Laws of Engineering," for which he was awarded the Melville Medal of The American Society of Mechanical Engineers in 1945.

1946-1947 Centennial Year for C.C.N.Y

THE City College of New York will celebrate during the 1946-1947 academic year the completion of one hundred years of service to the city, the state, and the nation.

Beginning on Oct. 12, 1946, when the official opening of the Centennial program will be marked by a dinner at the Hotel Astor, the program will continue through the academic year and close with the commencement exercises on June 19, 1947.

Representatives of colleges, universities, learned societies, and the government will participate in the public lectures, conferences, and social events that have been planned.

The City College of New York was established in 1847 as a free public institution for higher education by the state legislature and the City of New York.

President's Page

Salute to the I.I.R. Division

I HAVE just attended the first national meeting of the A.S.M.E. Industrial Instruments and Regulators Division which was held at Pittsburgh, Pa., Sept. 16–18, in co-operation with the Instrument Society of America.

The I.I.R. Division is the most recent of the A.S.M.E. family of professional divisions. It was organized in 1936 as the Committee on Instruments and Regulators of the Process Industries Division, and it attained the status of a professional division in 1943.

For many years a growing number of papers on industrial instruments and regulators have appeared on Society meeting programs, but the recent meeting in Pittsburgh was the first national meeting held by the new Division. High standards of quality have marked the technical papers sponsored by the Division. It has made progress in clarifying terms used in the field of instrumentation.

The growth of the I.I.R. Division is an indication of the growth of the Society. It is in line with the current tendency that mechanical engineering displays of extending its activities into the borderland between science and engineering. For the regulation and control of modern machinery, equipment, and processes which are based on the principles of applied science, the engineer must increase his reliance upon scientific principles which are fundamental to the design of instruments. The field of instrumentation is a rapidly growing one. The A.S.M.E. is fortunate in having among its members engineers who are pioneering in this important field. They add luster to the Society's long and honored tradition.

D. ROBERT YARNALL, *President*, A.S.M.E.

Note to A.S.M.E. Student Branch Secretaries

WHEN news of your Student Branch activities is published in MECHANICAL ENGINEERING your school receives national publicity and your alumni are informed of what is happening on their campus. What your branch does is important to others because your ideas may help other student branches in the planning of their programs.

For this news your school and the A.S.M.E. depend upon your reports of meetings, for without them neither your Society, nor your school, nor your alumni, nor other student branches can benefit from the efforts of your members.

You are urged to report meetings promptly so that accounts of them can be published in the earliest possible issue of MECHANICAL ENGINEERING. Material must be at headquarters one month in advance of the month of issue. For example, all news for the December issue must be at Headquarters on or before November 1.

You are urged to be accurate. Report full names of speakers, positions, company affiliations, and titles of papers.

Your full co-operation will make A.S.M.E. Student Branch news timely, accurate, and helpful.

A.S.T.M. Elects Officers

THE American Society for Testing Materials at its annual meeting held in Buffalo, N. Y., June 24 to 28, 1946, announced the election of Arthur W. Carpenter, manager of testing laboratories, The B. F. Goodrich Company, Akron, Ohio, as president of the society for 1946-1947.

Other officers elected were: vice-president, Richard L. Templin, member A.S.M.E., Aluminum Company of America, New Kensington, Pa.; members of board of directors, A. G. Ashcroft, member A.S.M.E., Alexander Smith and Sons Carpet Company, Yonkers, N. Y.; A. T. Chameroy, Sears, Roebuck and Company, Chicago, Ill.; J. H. Foote, Commonwealth and Southern Corporation, Jackson, Mich.; F. E. Richart, University of Illinois, Urbana, Ill.; and L. H. Winkler, Bethlehem Steel Co., Inc., Bethlehem, Pa.

S.E.S.A. to Hold Annual Meeting in New York, N. Y.

THE annual meeting of the Society for Experimental Stress Analysis will be held at the Hotel New Yorker, New York, N. Y., Dec. 9 to 11, 1946. The meeting will include a Symposium on Telemetering of Aircraft Flight Observations.

International Standards Body Secretary Resigns

H. J. WOLLNER, secretary in charge of the New York office of the United Nations Standards Co-ordinating Committee, announced that he has submitted his resignation there-from. This resignation was forwarded to James G. Morrow, chairman of the Executive Committee, which is the governing body. In undertaking the job of organizing western hemisphere activities of the Committee in 1944, Mr. Wollner had an understanding with the Committee that he would stay with the organization until June 30, 1946, by which time it was hoped a new international standards body, permanent in character and competently established, would have been created.

It is anticipated that when all of the national bodies meet in London in October of this year, the new organization will have been launched. Mr. Wollner, who has many years of industrial and governmental experience behind him, was previously consulting chemist to the U. S. Treasury Department and as such was attached to the staff of Mr. Morgenthau. He had technological supervision of the manifold scientific and technical activities of the Treasury including customs, international revenue, narcotics, and Bureau of Engraving and Printing. He anticipates returning to private practice.

Based on advice received by Mr. Wollner, but thus far not officially confirmed, the U.N.S.C.C. will probably close the New York office and carry on all of the international work through its London office. That office now has in preparation plans for the fall international meeting, part of which will probably be devoted to a study of some of the standards projects which have thus far been proposed. It is anticipated that advice as to the program of this meeting will be issued by the London office.

The membership of the U.N.S.C.C. now includes the national standards bodies of 18 countries as follows: Australia, Brazil, Belgium, Canada, Chile, China, Czechoslovakia, Denmark, France, Great Britain, Mexico, Netherlands, New Zealand, Norway, Poland, South Africa, United States, and U. S. S. R.

Student Branches

Alabama Polytechnic Institute Branch

On July 15 a meeting was held in Ramsey Engineering Building. Applications were given to potential members and MECHANICAL ENGINEERING was distributed to members. The president, William Smith, introduced J. E. Hannum, member A.S.M.E., dean of the school of engineering. Dean Hannum spoke on the origin and function of the A.S.M.E., and explained the objectives of the Society. Forty members were present.

A second meeting was held on July 29 in the Ramsey Engineering Building. The president, William Smith, turned the meeting over to Professor McKinnon who showed a film entitled "Making and Shaping of Steel." Announcement was made that Herbert Holdsambeck had been selected to receive the award given to the outstanding member of this branch.

University of Cincinnati Branch

The last meeting for the present school year was held on July 25 in the Student Union Building. The chairman read a letter from Dean Joerger to the branch in which the Dean spoke of the hard, but fruitful days of the future. New officers were elected as follows: R. Lippert, chairman; Wm. Emmons, vice-chairman; J. C. Rodgers, secretary; and G. Zeidman, treasurer.

Drexel Institute Branch

On Aug. 15 the annual summer meeting was held in the Drexel Student Building. The meeting was called to order by chairman John E. Herman, and during a short business meeting Kenneth Werner, William Linton, and Boris Kudravetz were appointed to represent the A.S.M.E. on the committee for Annual Engineer's Day. K. O. Miller, manager of steam apparatus, Middle Atlantic District, Westinghouse Electric Corporation, gave a talk on "Fundamentals and Applications of the Gas Turbine in Industry." The speaker covered the subject of gas turbines very thoroughly, explaining their application in stationary power generation, locomotive drives, and in aircraft jet drives. Particular attention was given to the gas-turbine cycles (simple open, reheat, reheat and regeneration, and intercooled) and the effect of inlet temperature and pressure upon them. An enthusiastic discussion of gas turbines followed the talk.

Missouri School of Mines and Metallurgy Branch

On July 12 the members met to view the showing of a film on the carbon-black industry entitled "Inside the Flame," produced by Godfrey L. Cabot, Inc. The film illustrated the construction and operation of a carbon-black plant and demonstrated the various physical and chemical tests to which the carbon black was subjected. After the showing of the film, E. Lindquist gave a lecture on the industry, covering the history and development of the channel and furnace processes. He discussed the various uses of carbon black in industry, especially the rubber industry, and discussed the expectations of its uses in the future.

Stevens Institute of Technology Branch

A meeting was held in Jacobus Hall on May 27. Prof. Gregory Comstock, director of the Powder Metallurgy Laboratory of Stevens, gave a talk on "German Industrial Development During World War II," supplemented with motion pictures which he took during a five-month post-V.E. day tour of Germany in the capacity of an intelligence officer for the Technical Industrial Intelligence Commission under the joint chiefs of staff. Professor Comstock said that many industries of Germany had remained unharmed during the war and that several specialized machines, found to be superior to existing Allied machinery, were crated and sent to America for study. The motion pictures included many views of the shambled factories hit by Allied bombers during the war, and also of underground factories whose machinery was left intact and on which Germany depended for industrial survival during the war.

On June 14 officers for the summer term were elected. They are: William Ellison, president; Elmer Chamberlin, vice-president and treasurer; Frank Ross, secretary.

The branch toured the Jacob Ruppert Brewery, one of the largest breweries in the East, on June 21. The tour was conducted in two sections, one of which was led by Fred Braun, director of public relations for Ruppert. The various phases of the beer-making process were revealed as the parties moved through the four-square-block brewery which is connected by underground passages. The ingredients of beer, the huge brewing kettles with a capacity of 700 barrels each, the large cylindrical fermentation tanks which, placed end to end, would form a continuous chain from Times Square to the George Washington Bridge, and all the power-plant installations were displayed and discussed. The power plant, supplying all the refrigerators, conveyers and various pumping devices, contains six 40,000-kw electric generators and various other large machines. After the tour was completed the party went to the beautiful taproom of the company, where fresh beer was served to the students, who drank in the interest of science.

University of Wyoming Branch

On July 11 in Engineering Hall a film entitled "Diesel, the Modern Power" was shown. This was obtained from the Bureau of Mines.

Refrigeration Exposition to Be Held in Cleveland, Ohio, Oct. 29 to Nov. 1

THE latest applications of mechanical-refrigeration and air-conditioning equipment to various manufacturing processes will be featured at the Fourth All-Industry Refrigeration and Air-Conditioning Exposition, to be held in the Cleveland Public Auditorium, Cleveland, Ohio, Oct. 29 to Nov. 1, 1946.

The exposition is sponsored by the Refrigeration Equipment Manufacturers Association with the co-operation of the Frozen Food Locker Manufacturers and Suppliers Association.

W. R. Whitney to Receive I.R.I. Medal

WILLIS RODNEY WHITNEY, pioneer director of the Research Laboratory of the General Electric Company, will receive the first Industrial Research Institute Medal during the fall meeting of the Industrial Research Institute, Inc., at a dinner at the Westchester Country Club, Rye, N. Y., Oct. 17, 1946.

Dr. Whitney is being honored for his outstanding contributions to the field of industrial research as a distinguished scientist, a pioneer of industrial research, and a leader and molder of men.

Dr. Whitney's career is reviewed by Dugald C. Jackson in an article "Willis Rodney Whitney, An Appreciation Based on Broderick's Recent Biography," published on pages 705 to 708 of the August issue of MECHANICAL ENGINEERING.

A.S.M. Nominates Officers for 1946–1947

THE American Society for Metals announced the nomination of Arthur L. Boegehold, research laboratories division, General Motors Corporation, Detroit, Mich., for the office of president of the society for 1946–1947.

Other nominations were: For vice-president, Francis B. Foley, superintendent of research, Midvale Company, Philadelphia, Pa.; trustees, John E. Dorn, associate professor of physical metallurgy, University of California, Los Angeles, Calif., and Arthur E. Focke, Diamond Chain and Manufacturing Company, Indianapolis, Ind.; secretary, William H. Eisenman.

Stevens Institute Honors A.S.M.E. Members

THE Stevens Institute of Technology, Hoboken, N. J., conferred upon Luis de Florez, member A.S.M.E., rear admiral, U.S. N.R., the honorary degree of Doctor of Engineering, and upon Paul W. Kiefer, member A.S.M.E., chief engineer, motive power and rolling stock, New York Central System, the honorary degree of Mechanical Engineer, at the commencement exercises of the Institute held June 22, 1946.

Honorary degrees of Doctor of Engineering were also conferred upon Robert C. Disque, dean, Drexel Institute of Technology, Philadelphia, Pa., and Frank C. Stockwell, professor of electrical engineering, Stevens Institute of Technology.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
29 West 39th St.	212 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, 25, married. Three years' aeronautical experience; layout, design, and testing. Thorough knowledge of plastics, wood, aluminum, and magnesium. Desires position in design or development. Location immaterial. Me-89.

MECHANICAL ENGINEER, age 42, twenty years' experience, designing and supervising construction and operation chemical processing plants, including materials handling. Desires position within engineering management or as executive assistant to top management. Me-90.

INDUSTRIAL ENGINEER OR ASSISTANT TO MANAGEMENT, 31, single. Graduate industrial engineer; 4 years' varied steel-mill experience in industrial engineering, production, labor relations, administration; 2 years' naval officer in expediting incoming shipments, contract termination, personnel, in ordnance plants. Location preferred, California. Me-91-468-D-1—San Francisco.

MECHANICAL ENGINEER, M.I.T. graduate, 20 years' experience machine design and development copper-refinery electrolytic equipment, wire drawing, elevator mechanisms. Me-92.

[1] All men listed hold some form of A.S.M.E. membership.

DESIGNER AND DETAILER light and heavy machinery. Also patent researcher, patent design. Diesel cycle—thermochemistry and thermodynamics. Plastic technologist connected with plastic chemistry. Age 45, salary on merit. Me-93.

CHIEF ENGINEER OR WORKS MANAGER; 38, married; desires job with sound small company. Graduate shop apprentice and mechanical engineering. Professional license. Sixteen years' well-rounded experience on drafting, tools, production, time study, cost, inspection, maintenance, welding, development, labor, personnel, suggestions, sales, organizing engineering department, and as acting works manager. Prefer Midwest or South. System and simplification specialties. Me-94.

PLANT MANAGER—GENERAL SUPERINTENDENT. Seasoned executive. Metal fabrication. Broad industrial-engineering background in all phases of management, plus excellent operating record. Unusual ability to handle labor and other personnel. Me-95.

GRADUATE MECHANICAL ENGINEER, 26, single, naval officer recently discharged. Previously one and one-half years' experience as aircraft-engine factory representative. Desires industrial or production-engineering work in East. Me-96.

EXECUTIVE ENGINEER, 46, married. Naval Academy graduate retiring in November with 22 years' experience, desires position as chief engineer of maintenance or operation or sales engineer. Location preferred, West Coast. Me-97-468-D-10—San Francisco.

MECHANICAL ENGINEER, 33, married. Graduate, registered; design, production quality control, executive experience. Eight years oil tool engineering, including design and sales. Accustomed to responsibility. Desires permanent position requiring administrative ability. Available in 6 weeks. Prefers Los Angeles vicinity. Me-98-468-D-20—San Francisco.

MECHANICAL ENGINEER, 33, married. B.S. degree from U.S.C. with experience in oil-pipe-line maintenance, several years' civil service, navy, yard ordnance work. Desires position in oil or rubber company or permanent work in small company in research and development. Available upon request. Location preferred, San Diego or Bay area of California. Me-99-469-D-1 San Francisco.

REGISTERED MECHANICAL ENGINEER, 31, married. Certificate in chemical engineering. B.S. in mechanical engineering. Experienced development, installation, and co-ordination work on Diesels and heavy-duty high-speed pumps. Desires sales engineering, development, or service position. Will travel but need place to settle family. Me-100.

MACHINE BUILDER, master's degree. Nine years' experience covering: Servicing, design, and project direction on accounting machines, computers, bombsights. Desires position as assistant chief or senior project engineer. $7000. Me-101.

POSITIONS AVAILABLE

MASTER MECHANIC, 35–40, to take charge of all building, plumbing and heating, electrical and mechanical equipment. Should have some experience in maintenance of foundry or similar equipment. Send record and attach snapshot. $5100 year. Ohio. W-7645.

PLANT ENGINEER, young, with mechanical-engineering experience. Must be capable of going into plant and taking care of many small engineering details relating to new installations, moving equipment, and some repair work. Starting $3000 year. Delaware. W-7659.

MECHANICAL ENGINEER, 30–40, graduate, with mechanical-design and shop experience in knitting or automatic-machinery field, to carry out additional development and instigate its manufacture and completion. Plant-engineering experience very helpful. $4800 year. Pennsylvania. W-7684.

MECHANICAL ENGINEER, 30–40, graduate, with 10 years' experience, some of which should have been in executive capacity and preferably some with automatic machinery. Should be capable of heading engineering department. $5000–$7000 year. Pennsylvania. W-7695.

EXECUTIVE ASSISTANT to managing director, 30–45, with production and cost control, and general administrative experience, to make cost and production analyses, etc., for leather-products manufacturer. $7500 up year. Tennessee. W-7727.

FACTORY MANAGER, 35–45, graduate mechanical or electrical engineer preferred, for plant employing 500 to 600 people, making electrical and metal products, to take charge of all factory operations including production planning, time study, and direct supervision of department foremen. Actual shop experience better than staff experience. To $10,000 year. Ohio. W-7733.

MAINTENANCE ENGINEERS, 2, who have had at least 5 years' experience in plant maintenance, to work directly under plant engineer. (*a*) One should have experience in paper-mill maintenance; (*b*) the other in pulp mill. Will consider men with maintenance experience on heavy equipment. Will supervise about 150 tradesmen. $5200 year. New England. W-7737.

SALES ENGINEER, 30–35, mechanical engineering graduate preferred, with oil-refining or power-plant-equipment sales experience, to be special representative of general sales department of valve manufacturer; will visit district offices, call on large and special accounts, etc. Considerable traveling. $3000–$5000 year plus expenses. W-7753 (*a*).

POWER ENGINEERS, 30–35, two, graduate mechanical, with several years' power-plant operation and maintenance experience, to make economic studies and assist in power-plant layouts. To start, $4500 year. Middle West. W-7757.

COMBUSTION ENGINEER, young, mechanical graduate, with thorough knowledge of combustion; fuel-burning equipment; city laws, ordinances, and regulations relating to smoke abatement; to lay out, assign, and supervise work of group of smoke-abatement inspectors and handle tactfully large variety of public contacts. Qualified to obtain professional engineer's license. $5000 year. Kentucky. W-7761.

SALESMAN for old and well-established southern marine and industrial repair plant, with machine-shop, marine-railway, steel-fabrication, and shipbuilding facilities, to estimate jobs, seek out and develop business. Excellent opportunity for young man to grow with developing business. Write giving detailed experience record, references, and salary desired. W-7783.

ENGINEERS, (*a*) Mechanical engineer, 35–40, with at least 10 years' experience in design and production of builders' hardware, to assist in development and improvement program for hardware manufacturer. (*b*) Warehouse manager with industrial and Army or Navy experience, to lay out space, select handling methods, and supervise general operations. $5000–$6000 year. Connecticut. W-7791.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after October 25, 1946, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

BALL, HAROLD W., Westfield, Mass.
BENTON, A. S., Atlanta, Ga.
BOCK, W. K., Cleveland Heights, Ohio
BRAUN, JOHN C., Pasadena, Calif.
BRIGGS, CHARLES W., Cleveland, Ohio
BRIMHALL, GEORGE B., Los Angeles, Calif.
BROWN, H. N., Ossining, N. Y.
CASGRAIN, WILFRED V., Detroit, Mich.
CERNA, WENDELL W., Pittsburgh, Pa.
CHAUVIN, LEO T., Hampton, Va.
CONABEE, R. S., Cardington, Ohio
CONNELLY, B. (CAPT.), Jackson Heights, N. Y.
COOKE, GEORGE, Stockport, Cheshire, England
COYKENDALL, L., Westfield, N. J.
CRAIG, STANLEY R., Marietta, Ga. (Re)
DEMCAK, GEORGE EDWARD, Raritan, N. J.
ECHOLS, L. S., Wood River, Ill.
FAHMY, HASSAN H., Giza, Egypt
FAJARDO-SUAREZ, EDUARDO, Caracas, Venezuela
FESSEL, ERIC, Washington, D. C.
FEURER, WALTHER A., New York, N. Y.
GALE, A. G., New York, N. Y. (Rt & T)
GANDHI, R. N., Sialkot Cantt., India